*Materials Engineering in Product Design & Manufacture*

# Materials & Methods

*January 1955*

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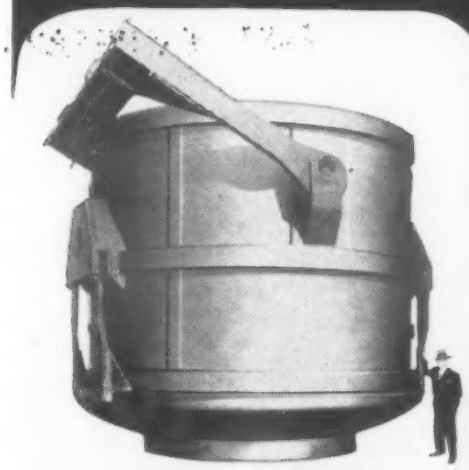

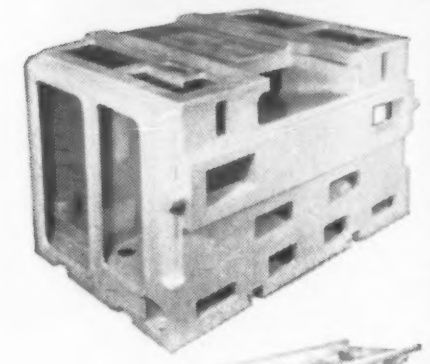

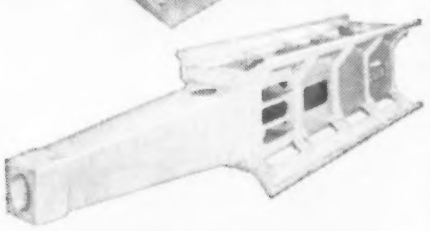

# Steel-Weld

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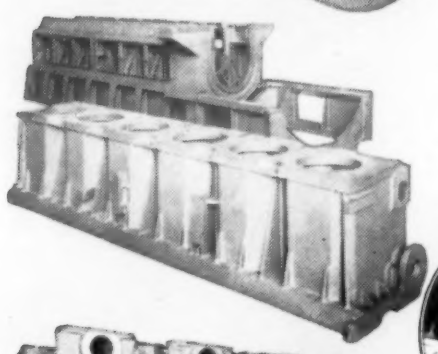

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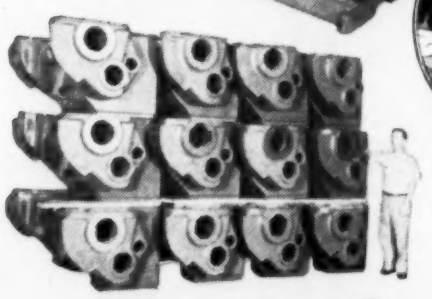

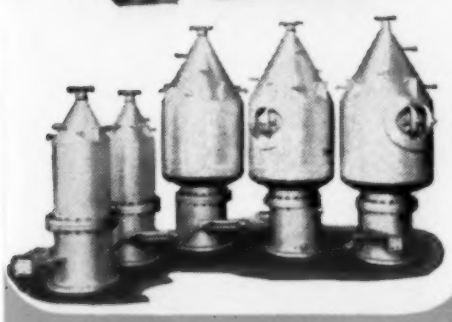

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# Materials & Methods.

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MATERIALS & METHODS IS INDEXED REGULARLY IN THE ENGINEERING INDEX AND THE INDUSTRIAL ARTS INDEX

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Suddenly, the lights snap on. Someone yells —

***"Don't move or we shoot!"***

How had the burglar been detected? No one saw him enter. No sign of an alarm system.

No obvious sign, that is. But there *was* an Alertronic Burglar Alarm.

This unusual protective device operates by sending out 19,200 cycle-a-second sound waves, too high for human ears to hear. The slightest movement of an intruder disturbs these waves and activates the alarm.

What produces the vibrations? Two slender nickel rods — and a principle of physics called magnetostriction (the peculiar way nickel changes length in a changing magnetic field).

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The search for a material with necessary magnetostrictive properties ended when he came to Inco. Nickel proved to be the material he was seeking.

And, as it turned out, he got more than a metal from Inco . . .

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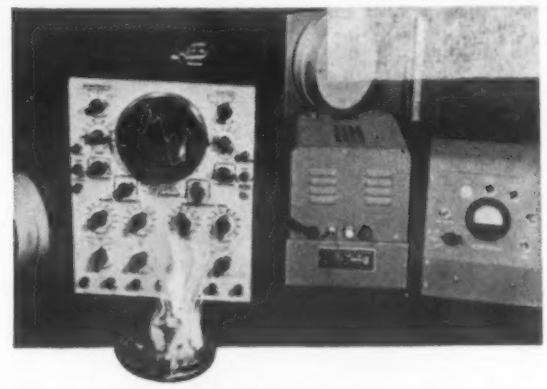
## NICKEL ITEMS

**Who can guess** what new use of magnetostriction will be announced next? Nickel transducers from little rods the size of match sticks up to ton-size blocks are already being used for killing germs by silent sounds, to measure ocean depths, to locate fish, for dust precipitation, for faster drilling of wells, for shaping gems and cutting tool materials so hard they normally have to be cut laboriously with diamonds.

**When installed** according to specifications of insurance underwriters and connected to central protective system, Alertronic enables users to qualify for 60% reduction in insurance premiums.



**Even the motion** of heated air from burning wad of paper in ash tray sets off Alertronic alarm as pictured by jumping lines of the oscillograph tube in this demonstration set-up.

**Inventor** Samuel Bagno, Vice President of The Ultrasonic Division of Walter Kidde & Co., Inc., flips a switch as he leaves his own plant to connect the alarm unit into Central Patrol Office.

**If you really want more facts** and technical data on the magnetostrictive properties of nickel, ask for our bulletin "Magnetostriction." It is written for engineers and physicists.

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**Fast Weld**

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**Back to Light**

Whale oil is back in the lighting picture. Only this time as an anti-corrosive agent for the aluminum bases of light bulbs.

**Needed**

The Atomic Energy Commission is urging more groups outside the AEC laboratories to do unclassified research in the metallurgy of uranium.

**Noisy**

Future jet aircraft for passenger use may have to have double shell fuselages to cut down noise in passenger sections.

**The Indian Way**

A manufacturer in Calcutta is keeping up with the times. His latest rickshaw models are paneled in aluminum.

**Hot Cobalt**

The largest piece of radioactive cobalt 60, delivered recently for oil industry research, emits an amount of radioactivity equal to 3,500 grams of radium.

**Quick Spud**

An aluminum nail inserted in a potato before cooking gets heat to the middle, cuts cooking time in half.

*(Men of Materials on page 9)*


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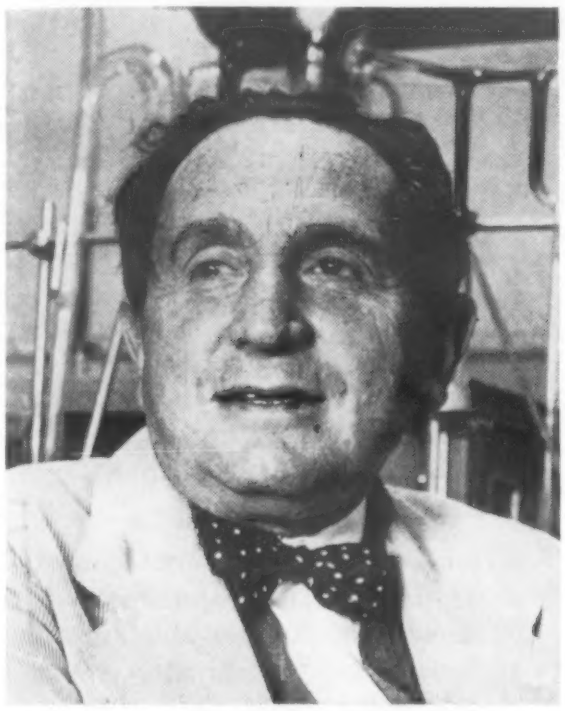
# Men of Materials...

*their views on development and utilization of engineering materials in industry*

**Paul Schwarzkopf**

*President*
*American Electro Metal Corporation*



Internationally active in all branches of powder metallurgy, Dr. Schwarzkopf was among the first to recognize that powder techniques offer a logical answer to high temperature materials problems. As early as 1911 he was engaged in production of tungsten and molybdenum and his subsequent achievements include development of multi-carbide tooling; the porous nickel cup used in proximity fuses; and more recently, new developments in boride materials and titanium. During his career he founded Deutsche Gluehfadenfabrik in Berlin; Vereenige Draadenfabriken in Holland; Metallwerk Plansee in Reutte; and American Electro Metal Corp. A prolific contributor to technical literature, Dr. Schwarzkopf is also the author of *Powder Metallurgy*, co-author of *Refractory Hard Metals*. He organized the international First Plansee Seminar in Reutte/Tyrol, and is preparing a second Seminar on "High Temperature Materials by Powder Metallurgy", which will take place in Reutte in June of this year.

"THE position of powder metallurgy in today's economy is secure, but we recognize that we are still only in the beginning phases of development and utilization. There is no doubt that the potentialities of powder metallurgy are far from exhausted, and we anticipate most important future developments.

"The use of sintered structural parts will expand substantially, due to economic advantages of the powder metal process, and research men can now leave it to the sales departments to overcome the inertia which still retards acceptance of sintered parts in standard applications.

"There exist many metallurgical problems which so far have not been solved. Today the two most challenging for the metallurgist are: first, high temperature materials—specifically a jet engine material with high strength at 1800 F; and second, the metallurgical processing of titanium and zirconium. Powder metallurgy definitely can supply some of the solutions.

"It is no secret that most of the so-called cermet materials which exhibit satisfactory high temperature performance are too brittle at room temperature for jet engine use. The problem of ductility should not be unsolvable, since certain percussion drill tools belonging to the same class of cemented hard metals have satisfactory room temperature impact strength. It is impossible to predict when solutions will appear, but in the meantime, many of the newer cermets have found important applications based on corrosion resistance at high temperature—for instance, in liquid-metal heat exchanger systems.

"As far as the powder metallurgy of titanium is concerned, initial difficulties have been overcome, and rapid developments will be forthcoming. The elimination of scrap loss is worthy of special attention in the case of titanium, because of the high cost of pure material and large scrap percentages with standard titanium forming methods. The extensive research work concerned with titanium now in progress will result, I have no doubt, in the powder metallurgical production of titanium compressor blades for gas turbines.

"The titanium scrap problem is formidable, as is the same problem with zirconium. The elimination of scrap by means of powder metallurgy will be significant, and may be even more important if large proportions of scrap can be utilized as raw material for powder metallurgical processing."

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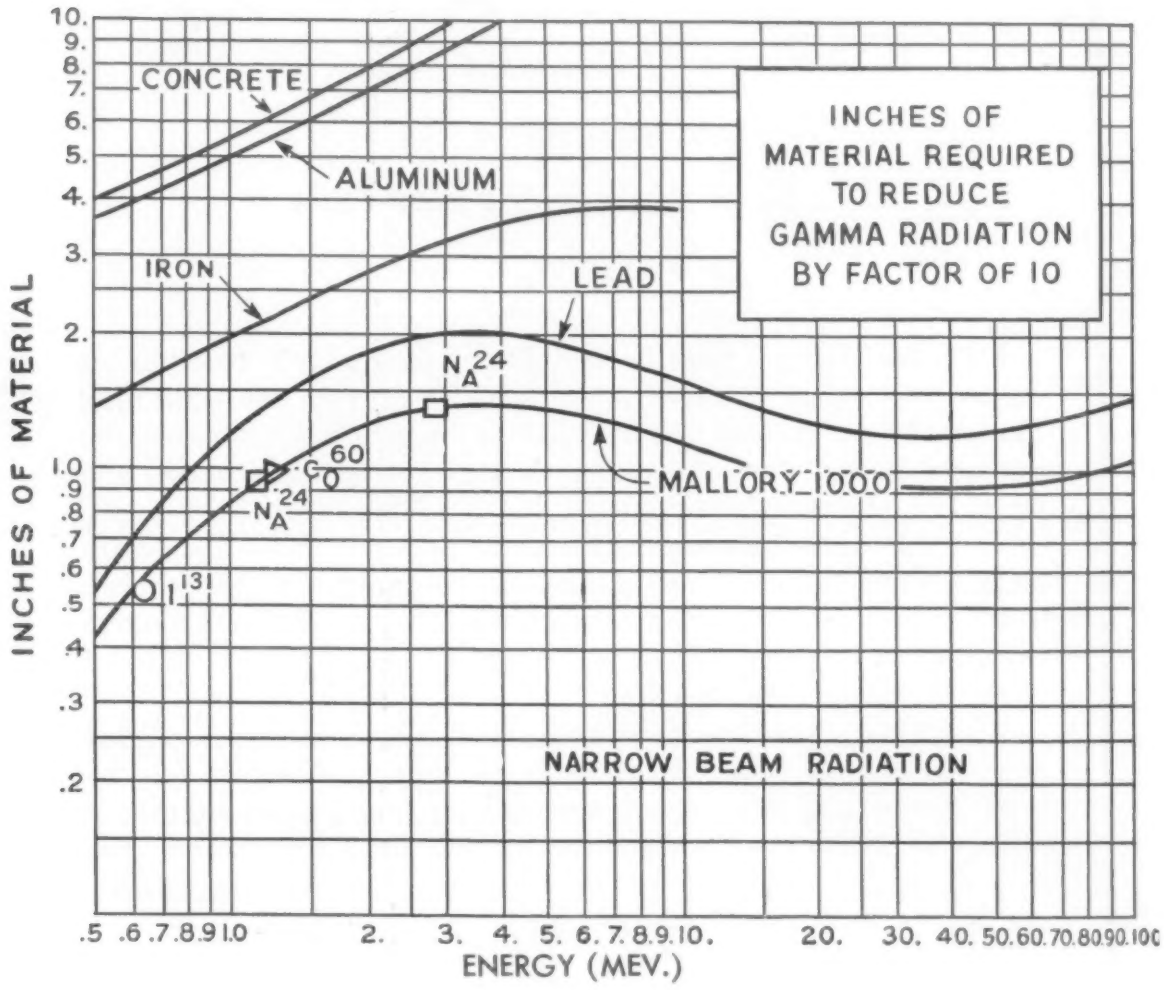
INCHES OF MATERIAL REQUIRED TO REDUCE GAMMA RADIATION BY FACTOR OF 10
CONCRETE
ALUMINUM
IRON
LEAD
$N_A^{24}$
$Co^{60}$
$N_A^{24}$
$I^{131}$
MALLORY 1000
NARROW BEAM RADIATION
INCHES OF MATERIAL
10. 9. 8. 7. 6. 5. 4. 3. 2. 1.0 .9 .8 .7 .6 .5 .4 .3 .2
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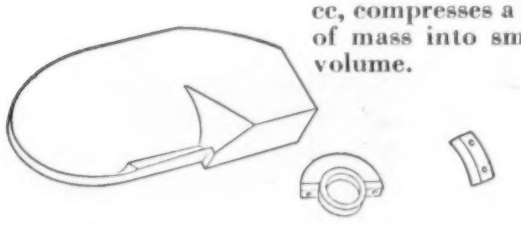

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## Aluminum Has Record Year

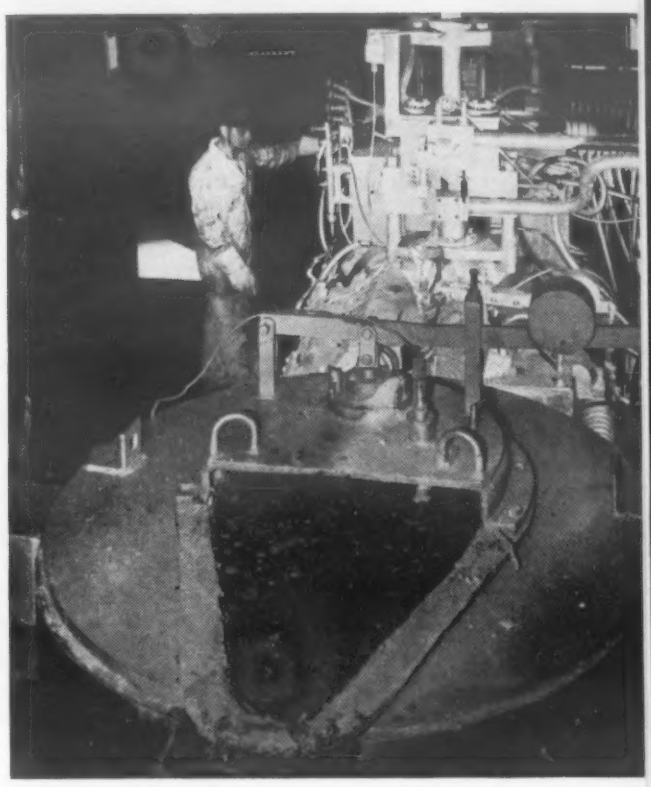
It looks as if a lot of housewives cooked their Christmas turkey in aluminum foil. That's one explanation of the phenomenal total of 150,000,000 lb of aluminum foil shipped in 1954, an increase of more than 30% over the previous year. Increased use of the foil is not attributed by industry spokesmen to any particular new application, but to wider use as a packaging material and increased use in the home.

All in all, 1954 was a banner year for aluminum. Total shipments neared 3 billion lb, or, 1½ million tons. This represents an increase of over 16% from 1953, the previous record year. In a year that witnessed not inconsiderable slipping and sliding in other industrial volume barometers, aluminum's performance was a stand out.

Aluminum gained ground in the automotive field, particularly for castings for automatic transmission components; the electrical industry used more aluminum conductors; the year saw more aluminum street and traffic light standards put up than ever before; materials handling equipment took advantage of aluminum's light weight; more went into building; and the use of aluminum truck and bus bodies increased.

Aluminum supplies in the future should be adequate, since the Aluminum Ltd. Kitimat operation is adding capacity, and a new American reduction plant is scheduled for operation early this year. The operation of the American plant will mark the completion of the so called "second round" of primary aluminum capacity expansion.

**Magnesium casting** from the hot chamber machine has minimum sprue scrap. Operator can give full attention to die, as metal feed is automatic.



**Molten magnesium** in the heated holding pot (foreground) is protected by a layer of flux. The pot is fed from the central melting furnace when level drops.

## Hot Chamber Magnesium Die Casting Cuts Costs

A successful hot-chamber die casting machine for magnesium has operated long enough to provide some definite cost analyses. Results assembled by Dow Magnesium may upset standard cost calculations for selecting zinc, aluminum or magnesium as a casting material. The figures indicate that magnesium die casting may become a much more attractive venture economically.

Here is how metal costs for 10-cu in. hot-chamber magnesium castings stack up against the same hot-chamber casting in zinc and cold chamber aluminum and magnesium:

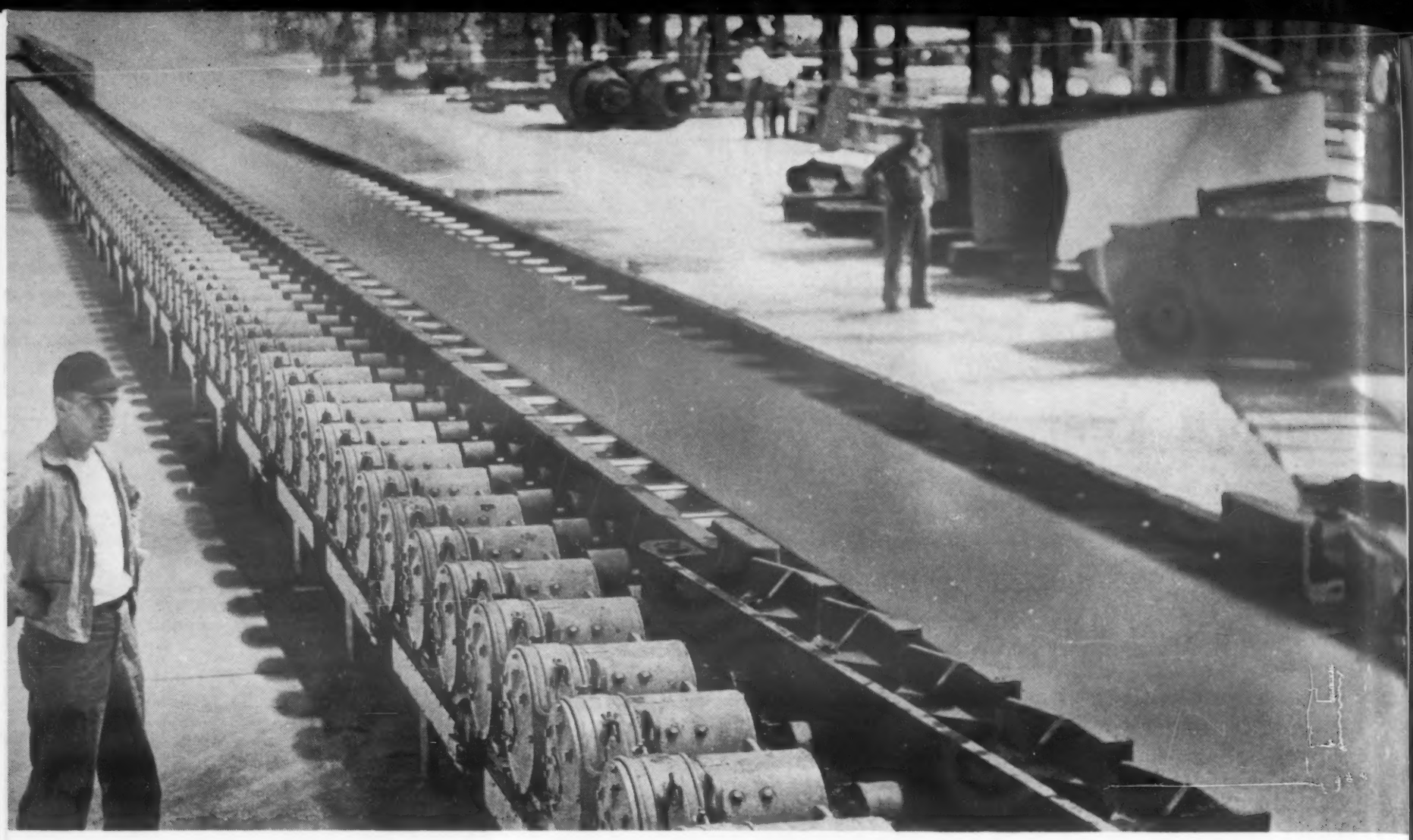
| | |
|---|---|
| Hot chamber magnesium | $0.195 |
| Cold chamber magnesium | 0.215 |
| Cold chamber aluminum | 0.217 |
| Hot chamber zinc | 0.367 |

The casting alloys used to derive these cost figures were ASTM XXIII zinc, SC84 aluminum, and AZ91B magnesium. The cost figures are applicable, of course, only in cases where all three metals are equally satisfactory, as cast, for final application. Corrosion problems requiring finishing operations would alter the overall cost relationships. However, the reduction in the basic price of magnesium in comparison to the other metals should be significant for many die casting applications.

### Hot & cold chamber

Cold chamber die casting requires that every casting shot be ladled into the cylinder or shot well, from which it is forced under pressure to the die cavity.

*(Continued on page 192)*



# 1954 Materials Developments

**Vacuum melting,** necessary for titanium and zirconium production, also saw increased use in production of specialty steels.

Materials, as such, seldom make headlines in the day to day news, but dramatic applications of materials developments constantly appear. The flashy offspring of better materials and more knowing design—the vertical-take-off Pogo aircraft, the bigger rocket, the sandwich wing of the guided missile, the transistorized hearing aid, and innumerable others—all followed by months, or even years, the basic materials developments to which they owe their existence.

In general, 1954 was a year of refinement of materials rather than a year of new discovery. In plastics, there were no new basic resins, but the developments of improved formulations of existing resins has paid off handsomely in improved properties and reduced costs. In metals, processes such as hot extrusion of steel and titanium, heavier extruded sections of aluminum, and improved heat treatment and joining, made more news than the development of new metals and alloys. Many of the offspring of these new refinements have not yet reached the market or the production stage. Some are through the pilot plant, others may wait years for the right moment when costs, market demand, and production facilities combine to make their application possible.

Materials developments combine to form a bank of opportunities for production and design engineers. The month by month increment in the wealth of this backlog as seen by MATERIALS & METHODS during 1954 is a dramatic indication of the dynamism of the constant search to provide better materials and processes that result in a greater variety of better products.

## The Year In Materials

**January**

■ Equipment is perfected for molding plastics pipe on the job in diameters of 6 to 60 in. ■ Introduction of NA22H, a heat resistant alloy for structural stability at 2200 F, by Blaw-Knox. ■ Tests conducted on Kentanium for 2000 F turbine impeller applications show signs of success. ■ Aircraft manufacturers, hunting for better materials for high speed aircraft, reveal tremendous market for titanium, are backed up by Army Ordnance which is planning to build more airliftable equipment. ■ Monsanto announces plans to build a polyethylene plant; another major manufacturer cuts polyethylene prices, and still another comes up with foamed polyethylene for a light, strong, electrical insulating material.

**February**

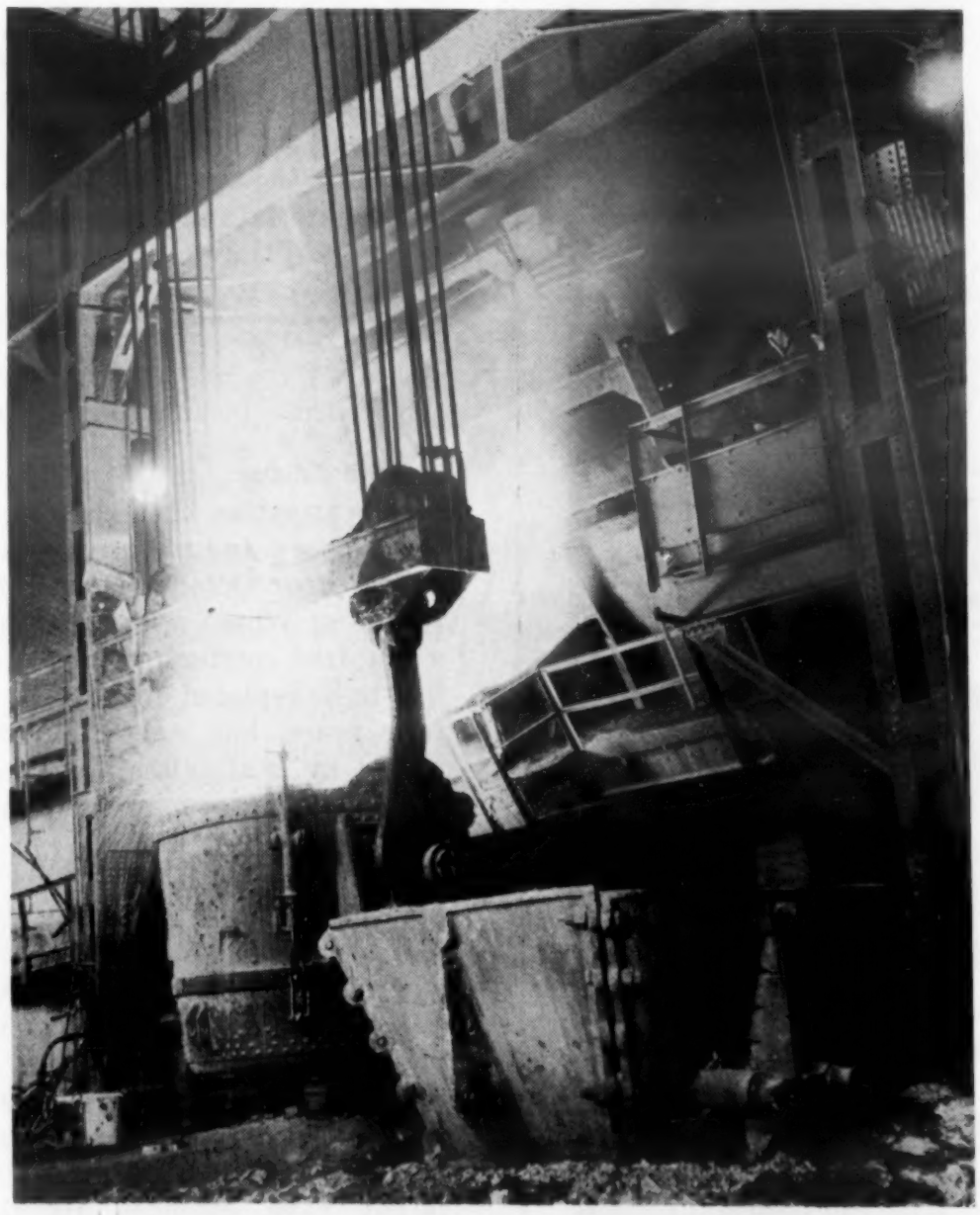
■ Aluminum for pressure vessels gets a boost from A54S, a new high-strength, weldable, non-heat-treatable alloy. ■ A British-developed laminated hard board is marketed here which holds promise for tooling applications. ■ A glass and an aluminum honeycomb is introduced for decorative and structural applications. ■ Hot steel extrusions are reported promising for aircraft components with shapes too complex to roll. ■ A new fire resistant polyester has fabrication and service properties equal to standard grades. ■ A silicone laminating resin is offered by Dow Corning Corp. ■ International Nickel introduces a new age hardening castable Monel alloy.

**March**

■ Du Pont reveals Mylar polyester film details, discloses plans for quantity production. ■ Disappearing extra charges show weak market position of steel. ■ Government prices for columbium and tantalum are raised to current market levels. ■ Nickel production incentives boosted by tax relief measures and Nicaro contract for Cuban mine and smelter expansion. ■ General Motors announces that its new GMR 235 superalloy withstands creep requirements at 35,000 psi at 1500 F—the alloy contains no cobalt or columbium. ■ Chromium manganese steels spotlighted because of the nickel situation—offered as possible substitutes for 18:8. ■ Sandwich materials are reviewed in the light of greater use in missiles and aircraft. ■ For the first time, commercial production schedules for vacuum melted alloy steels are put into effect as Vacuum Metals Corp. starts regular production of Ferrovac 52100. ■ Glass reinforced epoxy resin vessels are used at pressures up to 3000 psi share the new development stage with epoxy tooling, which is growing in acceptance.

**April**

■ Foamed polystyrene is introduced commercially. ■ Du Pont puts rigid polyethylene, Alathon 10, on the market. ■ Announcement of a serious attempt to perfect a ceramic coating suitable for ordinary carbon steel. ■ Bell Labs reveals that its zone melting purification techniques are applicable to many materials, including nonmetallics. ■ A new dispersing medium is introduced which permits coating aluminum and copper with fluorocarbon resins. ■ Further news on epoxy-glass reinforced pipe reveals that bursting strengths up to 100,000 psi have been achieved. ■ Thermenol, a new high-temperature aluminum - molybdenum iron - based alloy is reported to hold promise for corrosive, high-strength, and electric heater element applications. ■ Papers read at the annual metal powder show describe techniques for producing sheet materials from powder metals. *(Continued on page 14)*



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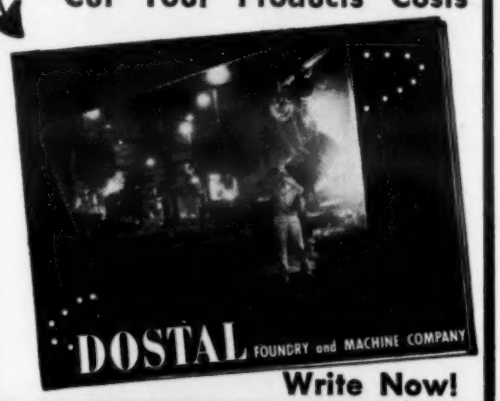


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# Materials Review

continued from page 13

**May**

■ Lodge and Shipley unveil Flo-Turning, a new automatic roll forming process. ■ Irradiated polyethylene with superior heat and chemical resistance is announced by General Electric under the trade name Irrathene. ■ Philips Laboratories releases a new technique to machine high density tungsten. ■ The BDSA authorizes a minimum set-aside for civilian applications of titanium. ■ A patent is issued for electrodepositing chromium directly on aluminum. ■ A new aluminum alloy, developed by Harvey Machine Co. exhibits ultimate yields up to 100,000 psi.

**New weapons** in production made use of many materials innovations.

**June**

■ A major producer of lead clad metals announces entry into rigid polyvinyl chloride fabrication business, serving to accent the trend of metal fabricators to supplement their lines with plastics pipe, tubing and corrosion resistant plastics tanks. ■ Synthetic mica is calendered into sheet suitable for high temperature service. ■ Titanium developments include: an improved mold material for casting, a 36% aluminum titanium base alloy, and a series of nickel-titanium brazing alloys giving joint shear strengths of 40,000 to 70,000 psi. ■ An all reinforced plastic delivery truck body is service tested. ■ Bell Laboratories demonstrates its solar battery utilizing the semiconductor silicon. ■ The Government reveals that industry is not using all titanium that is produced—and starts buying up the surplus. ■ Allegheny Ludlum and Harvey Aluminum report highly successful

*(Continued on page 196)*

# Letters

**To the Editor:**

Our attention has been drawn to the story and picture on page 116 of your October issue (Materials at Work) which shows a galvanized corrugated roof that had to be replaced every three or four years, but was finally replaced by a stainless steel roof which after seven years looks good.

It appears to us that this is obviously a case of using the wrong material for the purpose and is no reflection on galvanized sheets although this is implied. Under the conditions it could not have resisted the particular exposure unprotected although a surface treatment might have extended its life materially.

It is no wonder that the stainless steel stood up well under the conditions as these alloys are highly resistant to basic salt solutions.

Ernest V. Gent
Executive Vice President
American Zinc Institute, Inc.

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*There was no intent in publishing the item referred to to present galvanized sheet in a bad light. Our objective was to show that under extremely bad conditions it is often necessary to use more expensive materials to obtain satisfactory service life. In other words, the proper selection of materials is necessary for best results in almost any application one could consider.*—The Editors

# One point of view

*A progressive program*

From time to time in this space we have commented on the need for industry as a whole to encourage young men and women to seek their careers in engineering. The problem of getting people interested is one which will probably get worse before a turning point is reached.

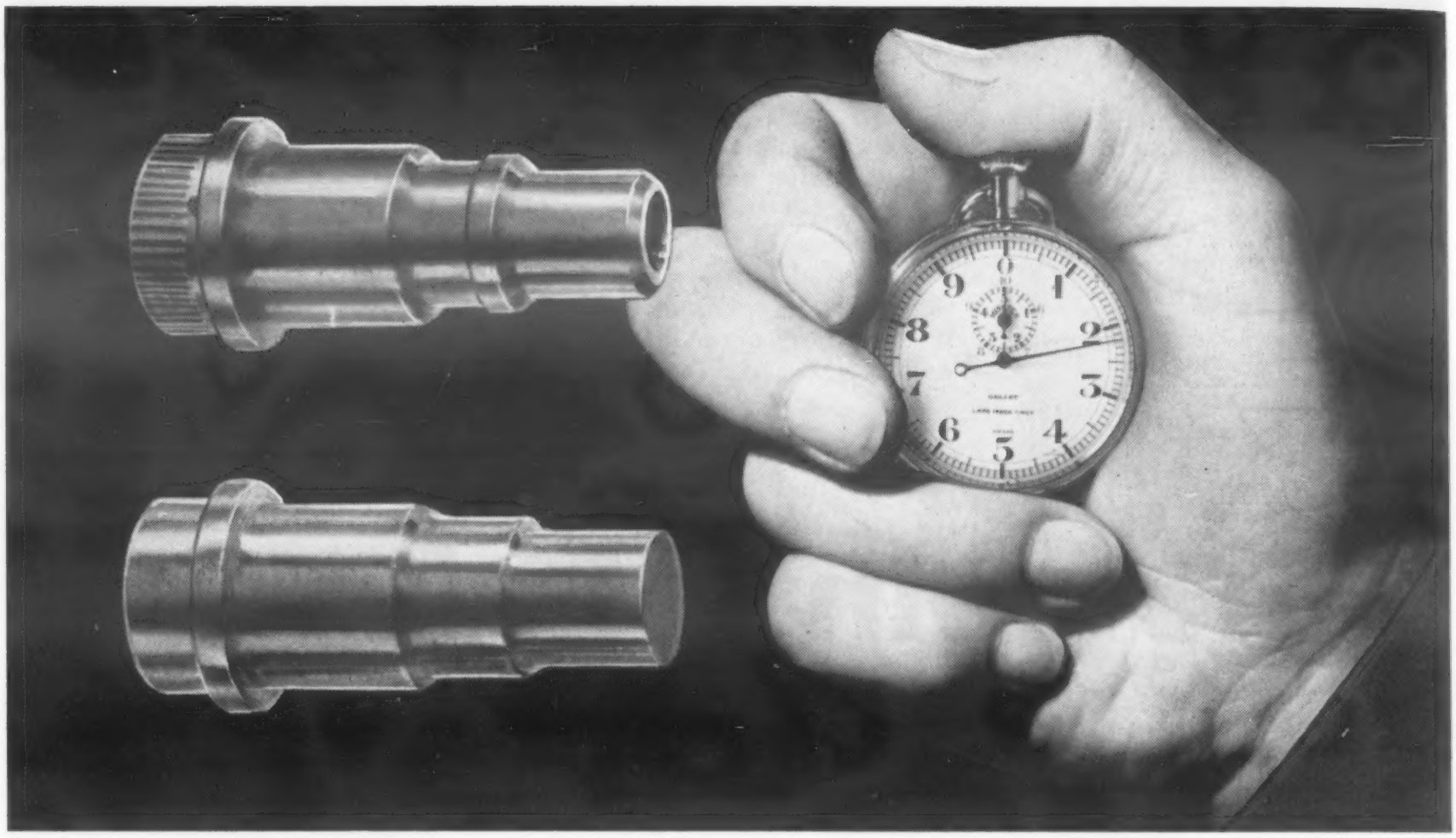
The day of the engineer is really upon us. Fighter aircraft are virtually flying electronic systems; digital computers and other electronic marvels are speeding up the development of engineering data. At the present time, we are on the threshold of learning much more about the materials we deal with every day. Automatic control is taking a strong hold on production processes. All of these developments require engineers. Engineers to produce them and engineers to operate and maintain the systems and equipment.

At least one company has faced up to this situation and has embarked upon a long range program to stimulate interest in engineering. That company is General Electric Co. Perhaps others are doing similar things, but we have not heard of them. Evidently believing that the best areas for development are in the minds of young children, General Electric has prepared a series of booklets patterned after comic books which show what engineering has done in the past and what it is likely to do in the future. Millions of copies of these and other pictorial presentations have been distributed through the nation's school systems. These efforts tend to dramatize engineering to highly impressionable youngsters. Perhaps the life of an engineer can be made to seem as glamorous as that of a fireman, policeman, or disk jockey.

As the next step, GE is trying to interest youth in mathematics and English. Both are essential in the modern world. All engineering is based on mathematics, and better English is needed for quicker and more intelligent communication of ideas. Both of these subjects are ignored in high schools so it has become necessary to stimulate interest externally.

There are other ramifications to the GE program, but the steps described are indicative of its scope. It will be interesting to see how well the program works. In the meantime, it would be well for other companies to see if they can't help on the immediate as well as the long range problem.

J. C. DuMond



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Representative models of the new Chrysler Corp. line-up round a curve on the proving ground test track near Detroit. L to R. Front row: Plymouth, De Soto. Rear: Imperial, Dodge and Chrysler.

## Redesigned Chrysler Line Reveals

# Automotive Materials Changes

*Chrysler Engineering Division staff men opened the hoods of their new products, spread out their specifications books, and told an M & M editor why they chose many new materials and techniques.*

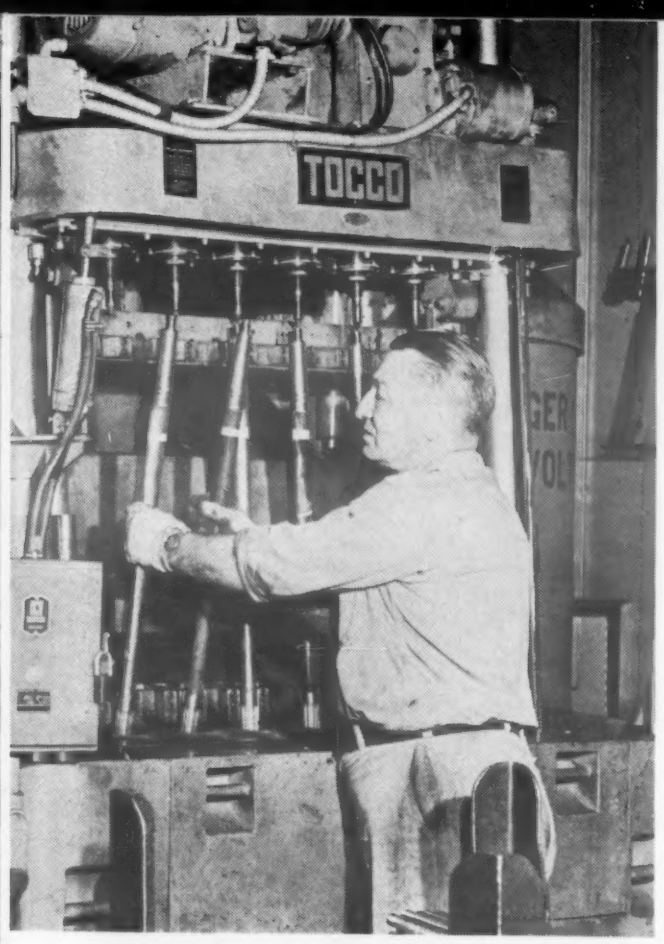
**by T. B. Merrill, Jr.,** *News Editor, Materials & Methods*

■ BECAUSE AN AUTOMOBILE is such a complex product, involving virtually the entire spectrum of engineering and decorative materials, few manufacturers in other industries face such a wide range of problems and choices in materials selection, design and engineering. On the other hand, virtually all manufacturers of mass-produced products, whether household appliances or artillery shells, find many of their own problems paralleled in one or another of the aspects of the manufacture of passenger cars.

In re-engineering and restyling all five lines of its automobiles, the Chrysler Corp. has made across-the-board engineering changes estimated to have cost over a quarter of a billion dollars. These major revisions, requiring extensive retooling, include a number of materials changes, which, Chrysler engineers believe, represent an optimum balance of the factors of quality, performance, appearance and production-economy. Some of the changes employ relatively new materials, such as Mylar sheet for interior trim; others reveal broader trends in the use of more common materials, such as increased application of flame- and induction-hardened carbon steels. The result, in the form of finished automobiles, represents a considerable investment of time, money and talent. It is well worth close examination.

### From Alloy to Carbon Steel

With this model change, Chrysler is cashing in on a long period of research and development of selective flame- and induction-hardening processes. Better processing permits use of less costly carbon steel. At the same time, it eliminates many




**Case 1** Rear axle drive shafts are induction hardened to .160-in. case depth on these automatic machines. Change to plain carbon steel from an oil quenched alloy steel gives 60% increase in fatigue resistance.

**Case 2** Hydraulic valve lifter. Change from chilled cast iron to induction-hardened or completely hardened hardenable alloy cast iron improves resistance to oil corrosion, wear, and scuffing.

warpage and machining problems, as well as extra processing steps. The toughness and fatigue properties of induction hardened parts are better, and above all, selective hardening puts the hardness where it will do the most good. With better control over physical properties, material cost reductions are frequently compounded by machining economies.

The fuel pump drive eccentric, which is the same on all V-8's in the Chrysler line, typifies the shift from alloy steel. Previously made of AISI 4028, carburized and hardened, the part is now fabricated from 1117 (a sulfurized, free-machining grade) carbonitrided and hardened. In addition to material cost economies, the 1117 improved machining speed by 30%, permitting existing facilities to absorb the increased production to cover new V-8 schedules. The carbonitrided part has better wear resistance, and yields an extra saving since the minor dimensional changes resulting from carbonitriding fall within tolerance limits and a finish grinding operation has been eliminated from the production line.

Other changes, including the rear axle shafts illustrated in Case 1, the torsional input drive shaft for automatic transmission, and clutch hubs for automatic transmissions follow the trend toward carbon steel. The clutch hub again involves a change from a molybdenum alloy steel to a plain carbon steel. The result is a higher quality part than would be possible through raising the alloy level, plus simplified machining and heat treating operations. A similar change on the automatic transmission drive shaft solved machinability problems and reduced warpage to a degree that, in spite of increased unit production, less straightening equipment and labor is required.

Connecting rods on the new models reveal a materials change coupled with a processing change that adds up to a better product at considerable cost savings. Connecting rods were forged from a hot-rolled, high carbon manganese steel bar stock, heat-treated and machined. The heat treatment involved batch quenching, which gave variable hardening values. By changing to plain carbon steel (1041) enough savings in material costs were realized to more than justify individual handling of the connecting rods on a continuous quench system. The net result was a better product from the standpoint of uniformity, with physical properties equal to the more expensive basic material.

### Alloy Steels Still Needed

Lest it appear that every materials change brought with it great savings or even improved properties at no extra cost, changes definitely exist which represent increases in both cost and labor. The new hydraulic valve lifters, pictured in Case 2, are an example. Previously made of cast iron with a chilled wearing surface, the valve lifters gave satisfactory performance with old-style petroleum oils. Accelerated tests of engines with new oils revealed that some, containing additives, increased the chances of tappet failure by corrosion fatigue. A lengthy test program involving more than 20 likely materials revealed that a hardenable cast iron alloy was the most satisfactory tappet material. Fabricated of the hardenable alloy (see case history) the part requires several extra processing steps, but it will withstand any "moose juice" a motorist pours into his crankcase.

Alloys of high nickel content are, of course, old standbys for corrosion resistance. Although Chrysler tries to cut down nickel wherever practical due to its unstable supply in a time of military insecurity it is not always possible to eliminate nickel because of its superior corrosion resistance qualities. Case 3, the torque converter oil cooler pass-

**Case 3** Oil cooler passage. Cupronickel clad steel provides adequate corrosion resistance for this part, results in 90% reduction in nickel over previous part, which was all cupro-nickel.

age, supplies a good example of nickel reduction. The part is subject to severe oil corrosion, considerably comlicated by the wide variety of oils and hydraulic fluids now available. As in the case of the valve lifter, materials must be able to withstand corrosive effects of a number of agents to survive almost anywhere in modern automobiles.

One of the parts most subject to corrosion is, of course, the muffler. On the Dodge, De Soto, Chrysler and Imperial lines, galvanized steel is used to extend muffler life. Previously made of plain cold rolled steel, the switch to galvanized and aluminized steel also involved a considerable modification of welding procedure to compensate for the more difficult welding characteristics of the coated stock. The reasoning behind the change is that mufflers on new high performance engines are an expensive replacement for the car owner, and because of the dual exhaust system on the Chrysler and Imperial, the need for longer life is underscored. This again is an example of a rather costly materials change resulting in no obvious performance change, but leading to better long range service.

Welded assemblies are getting more and more attention at Chrysler, and they expect to use more of them in the future. On '55 models, the rear spring hanger has been changed from a casting to a welded assembly. Stamped and welded parts are usually much less expensive than castings, and they also cut processing steps and offer a greater choice of material.

Castings are in a good position, particularly hardenable alloys and pearlitic malleable. They will be around for a long time, say Chrysler men, particularly because of their desirable noise damping factors in such parts as differential housings. The development of improved permanent-mold casting techniques for iron make iron castings more attractive from a cost standpoint; for example, the Dodge oil pump cover casting which is illustrated in Case 4.

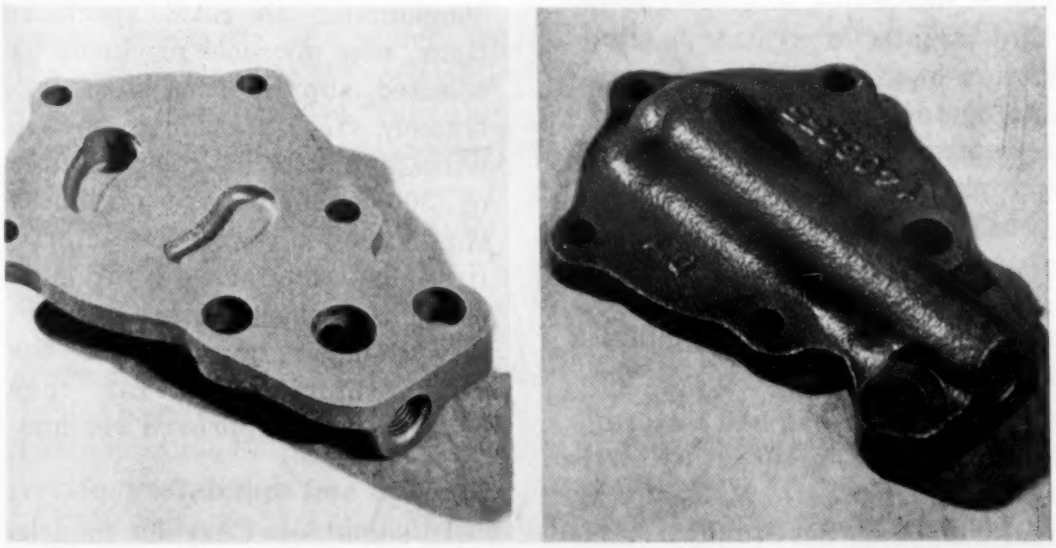
### A Place for Aluminum

The Chrysler Engineering Div. has a special staff assigned to concentrate on applications of aluminum. Dodge has 136 aluminum components, the Chrysler *New Yorker* has 116, and the Plymouth has 127. Importantly, the trend of aluminum applications is more and more to stress-bearing, functional parts, and the metal is also nosing into exposed, decorative applications.

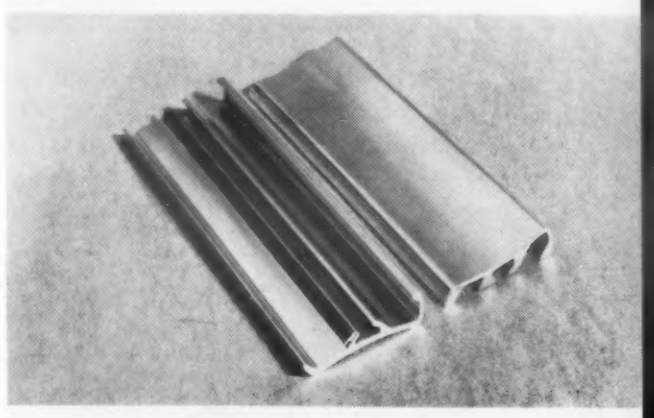
Chrysler has used aluminum to a greater extent than other automobile manufacturers for many years, and from all indications they will keep on using more and more. Despite zinc's price advantage for small, complex die castings such as fuel pump and carburetor housings, aluminum's light weight, higher strength and good corrosion resistance have won out. That light weight has a great deal to do with the selection of aluminum is revealed by the fact that specifications for many die cast parts give an option of aluminum or magnesium. Aluminum now enjoys a price advantage, and is thus selected.

In the Plymouth, parts of aluminum which are typical of the entire Chrysler line include: power hydraulic steering gear housing and bulkheads; most of the major components of the automatic transmission, with the exception of the gears; pistons and cylinders in the braking system; valve rocker shaft brackets; steering-post brackets, caps and covers; and many others. Aluminum is not all hidden. Many components of instruments, including dials, name plates, and pointers are made of aluminum. The front door sill plate is aluminum. Chances are excellent that bright finished aluminum in natural and metallic colors will find its way into dash panels and other decorative positions before long. An aluminum extrusion used in the interior treatment of some models is illustrated in Case 5.

The good physical properties available in impact-extruded aluminum components have re-

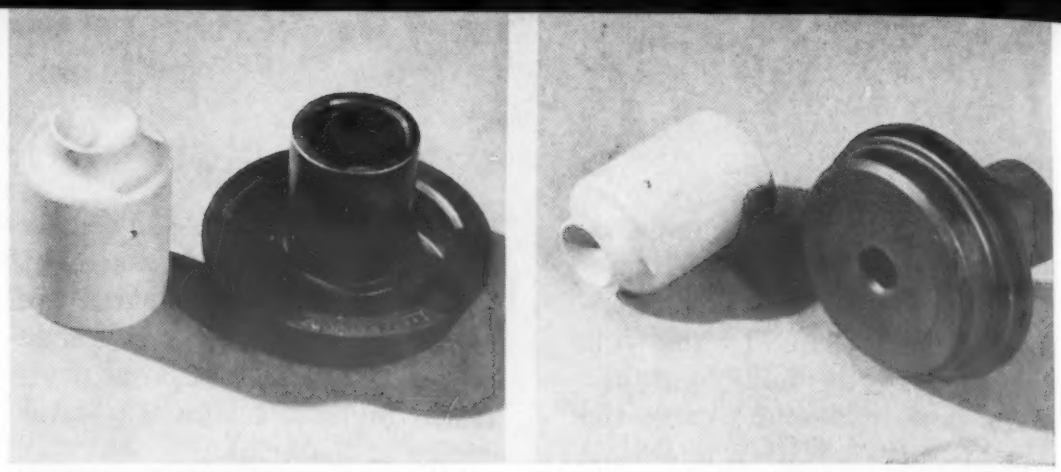


**Case 4** Oil pump body cover. Change from gray iron sand casting to permanent mold iron casting reduces costs, gives better surface free of abrasive particles. Closer tolerances reduce as-cast weight.



**Case 5** Seat cushion molding. Extruded aluminum molding, chemically brightened and anodized, gives good service and appearance. Low tooling costs give competitive piece price.

sulted in their selection for transmission servo pistons and piston sleeves, (see Case 6). Where spark plugs are buried they have impact extruded aluminum covers.

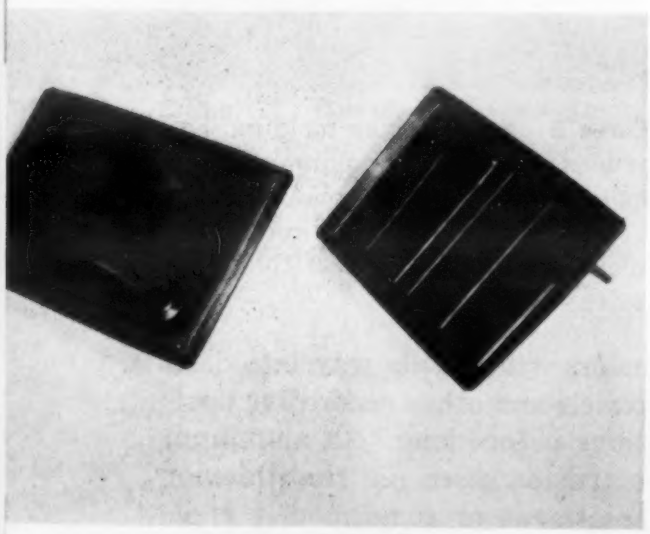


**Case 6** Transmission servo piston and piston sleeve. Piston sleeve is cold impact extruded aluminum (61S) and piston is anodized die casting of aluminum (A-380). Both parts were previously machined from steel bar stock. Aluminum provides adequate strength and bearing properties, cuts machining cost.

### Functional Rubber and Plastics

Most of the materials changes involving plastics and rubber occur in interior treatments, but several strictly functional parts are worth noting. The general trend is not so much toward the use of new resins as it is toward modifications and quality control of standard resins and rubbers.

**Case 7** Heater housings. Sisal reinforced polyester molding has better corrosion resistance than sheet steel used previously. Matched die, one-piece molding reduces labor costs in assembly.



**Case 8** Battery tray. Change from phenolic resin impregnated paper to semi-hard rubber provides more serviceable part.

The most impressive use of plastics for an assembly is illustrated in Case 7. Combined heater-defroster units are now molded of sisal-reinforced polyester resin. The whole assembly is made in two matched-metal-die moldings—one for ductwork on the cab side of the firewall, the other on the motor side for heater coil cover, ductwork and blower-motor support. The moldings are large, covering almost the entire width of the dash. Chrysler estimates that these two moldings alone will consume more polyester resin than is used by any other automobile manufacturer.

The material cost of polyester resins for the heater is above that of steel, particularly since the assembly must be of equivalent weight to provide suitable sound deadening characteristics. The savings in assembly, elimination of sealing and spot welding operations, and the improved appearance and serviceability of the plastic part more than compensate for increased material cost. The use of sisal rather than glass reinforcing fibers helps to keep cost down, and simplifies molding and lay up.

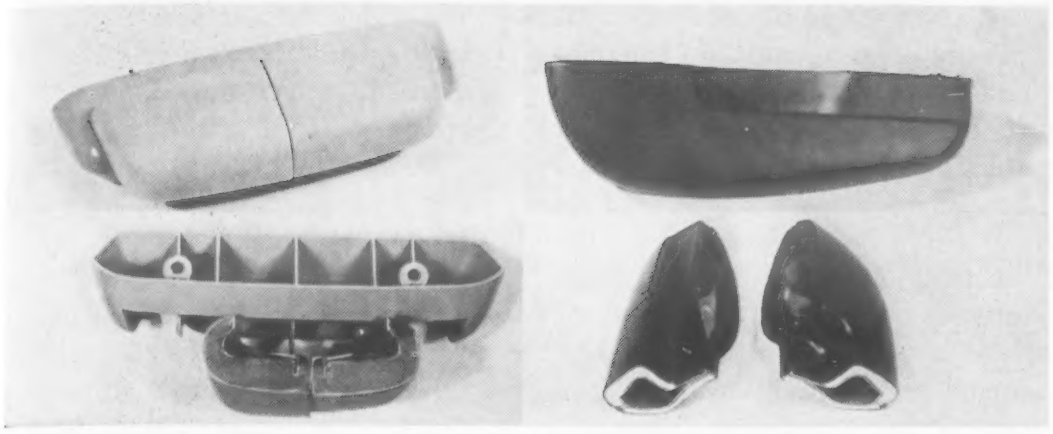
Anyone who has had a storage battery rack corrode out will welcome the change in battery tray material (Case 8). Simply a semi-hard rubber tray with raised edges and a long drainage tube, the part replaces a phenolic-impregnated tray. The rubber tray has equivalent, or better, corrosion-resistance, costs about the same to manufacture, but is much longer-lived and more capable of preventing the spillage and seepage that corrodes the inside of the fender and engine parts.

Automobile air conditioners have presented a considerable problem in installation and servicing due to the copper tubing used to conduct Freon 12. Chrysler is now using a hose, with Buna-N tube and neoprene cover for this purpose on the low pressure side of the system. Buna-N inside a braided fabric reinforcement, resists the action of liquid and gaseous Freon. The tube is gas tight and a neoprene outer covering gives adequate weather and abrasion resistance. The slight flexibility of the tubing acts as a natural hydraulic noise damper, resulting in quieter air conditioner operation.

Buna-N is also in the spotlight for high temperature resistant O-rings and seals. Previously compounded to SAE specifications, new oil seals produced by selected suppliers to meet extremely rigid specifications will withstand oils at temperatures of 300 F, and have minimum shrinkage and swell characteristics. The engineering division cautions that this rubber cannot be produced by "run of the mine" suppliers. So far, they have only five approved vendors.

### Plastics and Upholstery

In some new Chrysler models, it is possible to sit on, lean on, step on, and look at vinyl, all at the same time. The soil, weather,



**Case 9** Arm rests. Vinyl foam with integral vinyl plastisol skin molded simultaneously gives homogenous part, saves assembly labor, permits design freedom not attainable with fabric or coated fabric cover over foam or padding.

and abrasion resistance and wide color variety of the material has caught on with designers, stylists and engineers alike. Vinyl is used in many different forms, and is combined ingeniously with metals, fabrics, and other plastics.

Decorative and functional arm rest cushions in all five automobiles make use of metal stampings, vinyl foam and vinyl plastisol. The parts are made by two processes. In one case, the metal insert is placed in the mold, the plastisol slush molded to form a skin; then the vinyl foam is injected into the die subsequent to the curing operation. The second method involves spraying the plastisol on the open mold surface, then putting the insert in place. The mold is then closed and the vinyl foam injected. Bonding is excellent between skin and foam, since the material is essentially homogenous. An adhesive coating is applied to the metal stamping before molding to provide a bond from the metal to the foam. The part costs less because of assembly economy, and greater freedom of design is possible since this type of molding makes possible indentations, hand grips, and odd contours that could not be made of fabric-covered padding or foam rubber. Case 9 illustrates two versions of the part.

The instrument panel of the De Soto (Case 10) and the seat back of Dodge station wagons show an application of textured vinyl paint. Conventional spray painting methods apply the coating, which replaces flexible plastic sheet cemented to the sheet metal on dash applications, and rigid sheet on the seat back. The non-glare coating has good abrasion resistance, cleans easily and is less costly.

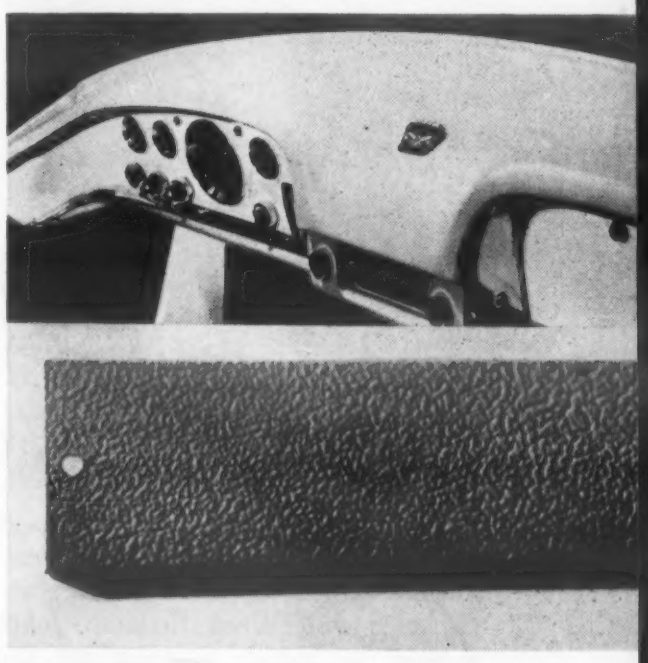
The wear and appearance properties of imitation-leather plastic-coated fabrics for station wagon and convertible upholstery are marred somewhat because the fabric does not breathe, and seats become sticky from perspiration. Case 11 shows a porous vinyl coated fabric which overcomes that disadvantage. Vinyl is spotted on the fabric in a raised pattern which allows air to circulate between the seat and sitter. The woven fabric has less elasticity than the knit back material used previously, which makes assembly a little more difficult.

In all cars not using carpets, a vinyl coating is applied over the rubber-base material used in floor mats. The coating gives about thirty times the wear of colored rubber coatings. Calendered or sprayed on uncured rubber stock, its price is competitive, and pastel, metallic and higher luster colors are available. The harder surface resists the grinding action of dirt and is more easily cleaned. The vinyl coating is about 0.003 in. thick.

Supported embossed vinyl sheet in the Plymouth Belvedere door panels matches the seat upholstery color and pattern so closely that it defies visual identification. The material is embossed and printed in two colors and two patterns in one operation, which makes it comparable in cost to fabric or coated fabric, but supplies greater wear resistance and cleanability.

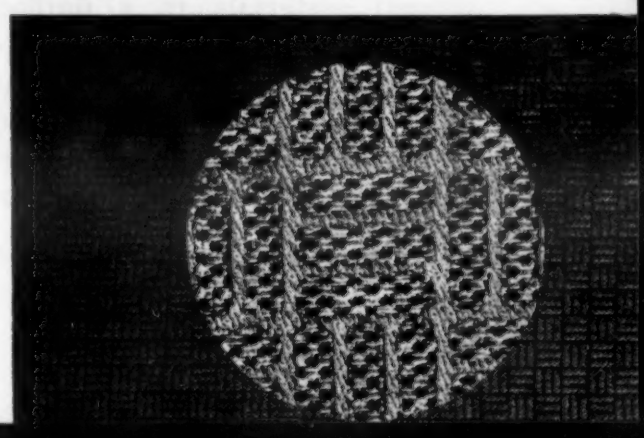
Chrysler has switched from rubber to vinyl for weather sealing on some vent windows because of better ozone and weather resistance. Produced on fast injection molding equipment, mold and molding costs are less, and the product has better color match with the rest of the automobile and retains its gloss.

In Case 12 Mylar is the outstanding material, but it is backed up by vinyl. One-half mil Mylar sheet, aluminized by the vacuum vaporization process, is

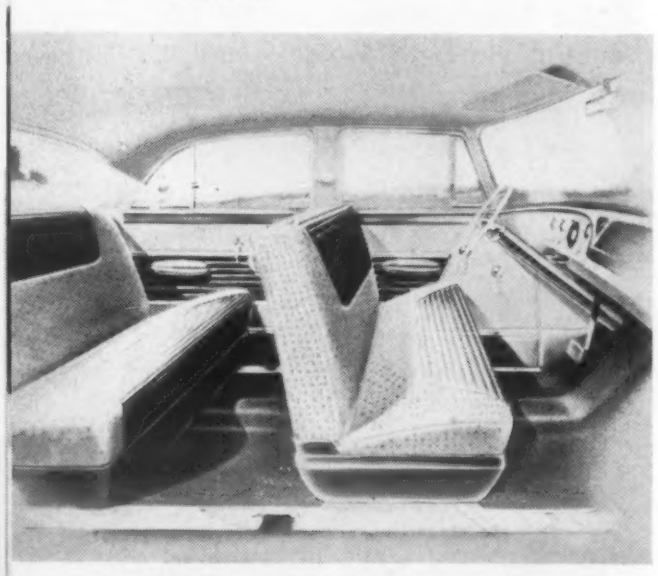


**Case 10** Textured vinyl coating. Applied by conventional dip or spray paint methods, this coating offers good appearance and wear, eliminates cementing, heat forming, needed with sheet-covered metal.

**Case 11** Upholstery. A vinyl-coated fabric that breathes replaces imitation leather. Raised pattern of vinyl is spotted on fabric, permitting air passage through material. Is more comfortable in hot weather, has good wear qualities.



**Case 12** Door panel insert, seat welt. Though matching bright-plated metal in appearance, the door panel on the Dodge is metallized Mylar, backed by vinyl sheet. Seat welt is same material, matching door panel and other chrome details.



**Case 13** Upholstery material. A three-ply, stitchless material provides a quilted appearance. Acetate tricot is vulcanized through foam rubber to cotton backing on the seat cushions.

bonded to vinyl sheet and embossed. Used on seat welts, the chrome-like color matches both car trim and metallic thread in the fabric. Despite fewer suppliers and higher cost, the wearing qualities and appearance of this material dictated its use.

Some non-vinyl materials show a trend toward combining several materials in a unified configuration, such as the stitchless quilting obtained by vulcanizing acetate tricot fabric through a thin layer of foam rubber to a cotton sheeet backing. As seen in Cases 13 and 12, the material appears on the door panels and seats of several cars. It has particularly good wear and fade resistance. Almost any fabric or coated fabric will do for the outer coating, and the quilting pattern is infinitely variable.

A large vacuum molded preformed piece forms the headlining in the Plymouth Suburban, replacing a woven paper fiber. Made at comparable cost, the heat formed rigid sheet prevents dust penetration, can be cleaned by wiping, and is much simpler to install.

In the higher priced models of the Chryslers, a sponge-back nylon filament carpet has replaced the jute back carpet used previously. The bright, lively sheen of the filament facing is better than that obtained with staple, and it is cleaned more easily.

Despite all the new synthetics and sponge rubber, jute mat remains the best sound deadening material from a cost standpoint, and is used under all flooring. An equivalent weight of other material would not be better, and would certainly cost much more.

### About Chromium Plate

No discussion of modern automobiles would be complete without mention of chromium plate and techniques to keep it shining with a minimum of nickel consumption.

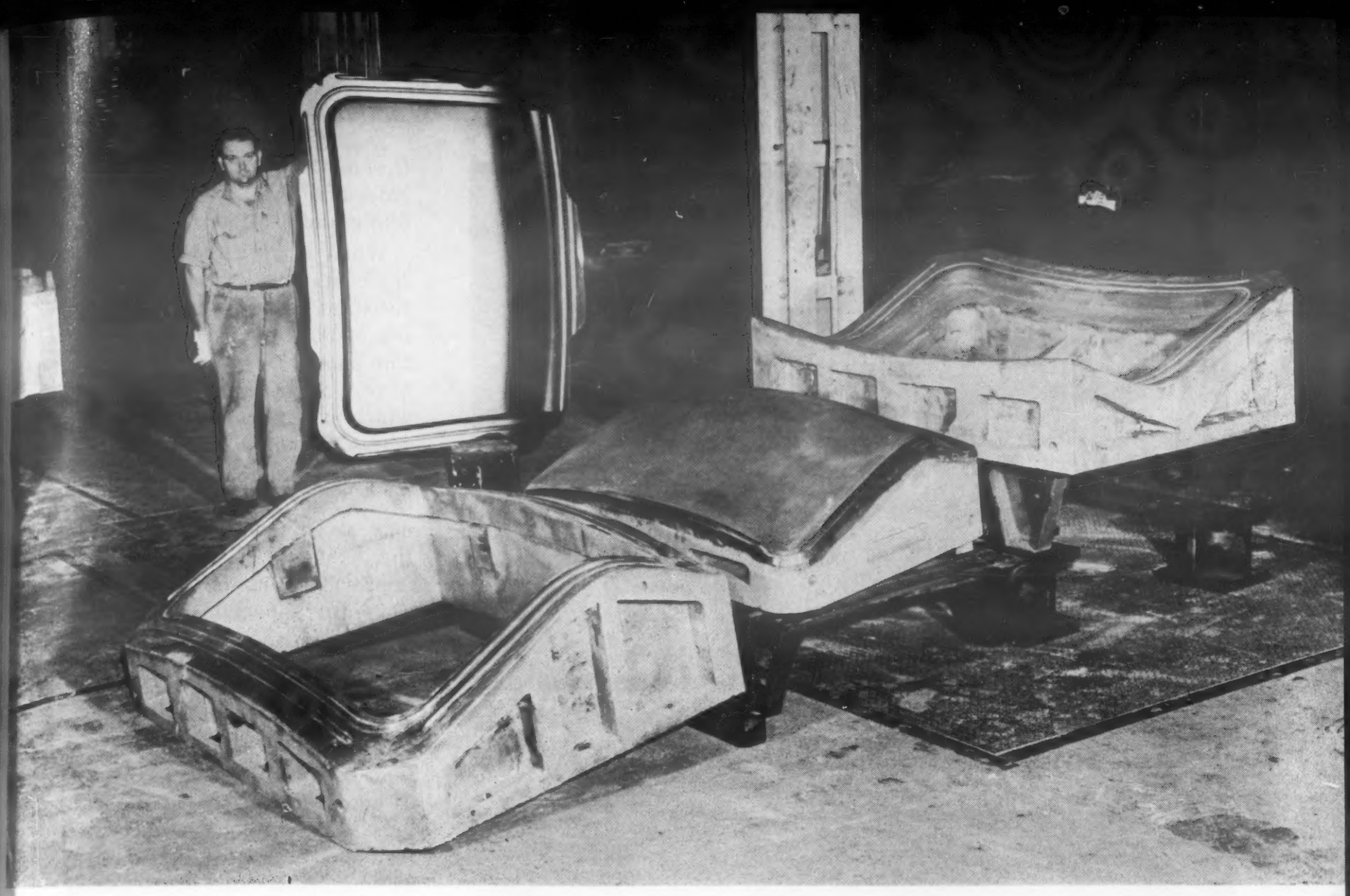
Chrysler uses a chromium stainless steel wherever possible on exterior trim. On higher priced models it is chrome-flashed to give a more exact color match. The chrome-flashed stainless holds up better in industrial atmosphere than does copper-nickel-chromium plating, but this does not show in salt spray tests.

Despite the tendency toward the use of less nickel, the nickel plating on zinc based die-cast parts, such as headlight bezels has been increased from 0.0003 to 0.0005 in. minimum to 0.0008 in. minimum. Since the corrosion resistance is proportional to the thickness of the nickel deposit, this increases the resistance to corrosion about three times.

A new, longer-life, nickel coating is applied to bumpers on all models by a new process which gives a thicker coating but uses a minimum of nickel. Bumper plate must be ductile enough to withstand impact, so until this change, a semi-bright ductile nickel was applied, then buffed and plated with the usual 0.00001 to 0.00002 in. of chromium. The new process first plates the bumper with ductile nickel, then, in the same plating line, deposits a bright nickel coat. Buffing is not needed, giving a more consistent nickel thickness. Up to 25% of the nickel can be bright-plated without adversely affecting ductility. The double nickel coat eliminates practically all pinholes and defects as it acts as a sandwiched layer; eliminates buffing equipment and labor; gives a smoother, more durable finish; and eliminates buffing loss of nickel.

### An Eye on the Auto

This glance at some of the changes in a line of automobiles is only a brief, partial chapter of the record of the continuing search to find better ways to produce one of manufacturing's most complex products. It illustrates how all directions are probed for improvements. And it demonstrates how, when investigations show pay-dirt, they are probed to the limit. The difference of a few pennies in the cost of a part made with a different material or by a different method, looms large when multiplied by the seven figure total of unit production. A relatively small change, whether it is the result of only a few days or, as is more often the case, many years of research and testing, is frequently represented by a million dollar figure in the balance sheet. Chrysler and the rest of the automobile companies know this, and do not skimp on investigations. They are important people to watch.



The face of this die cavity and punch for an automotive luggage compartment door is made of ⅜-in. epoxy-glass laminate backed with a zinc alloy base. Parts are formed in cold-rolled 0.036-in. steel. Die has formed 100 stampings to date. *(Bakelite Co.)*

# Plastics Tooling—

## Its Place in Industry

*Part 2* | *How are the tools made?*
*How long will they last?*
*What do they cost?*

*This second of two articles gives the answers and discusses briefly some developmental applications of plastics tooling.*

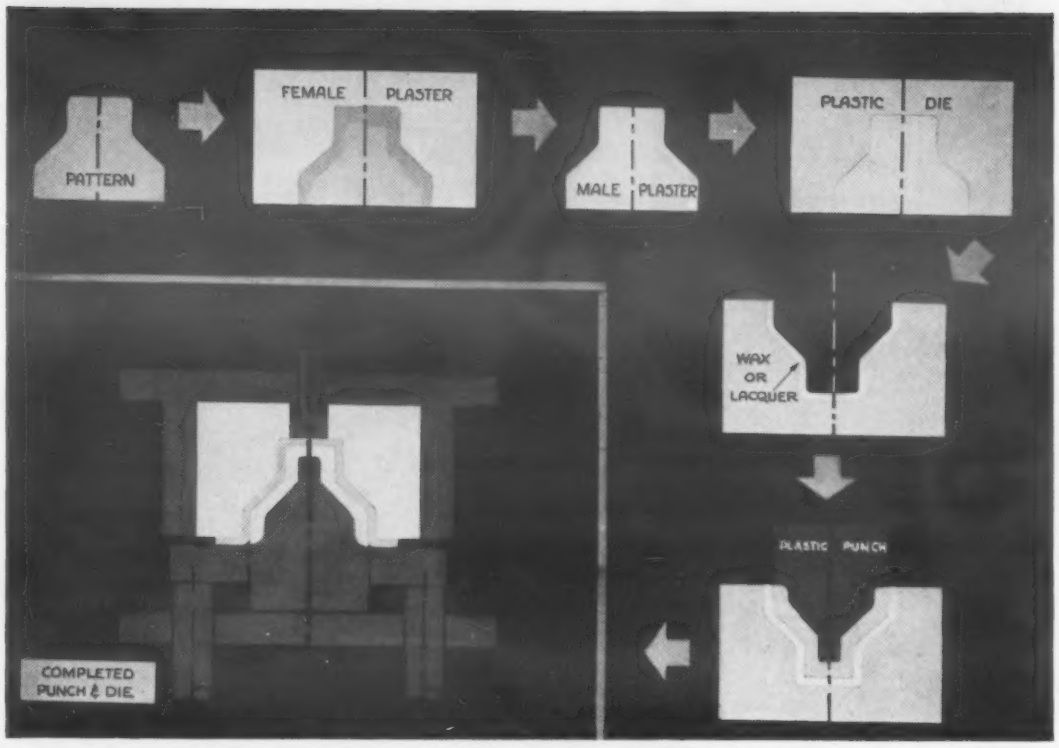
**by Malcolm W. Riley,** *Associate Editor, Materials & Methods*

■ THE PROPERTIES of a cured plastics part depend to a great extent on the method of fabrication used to form it. Since each plastics tool is built to meet different service conditions, the methods of fabrication employed are highly important. At the present time, casting under gravity feed, laminating under contact pressures, or a combination of both of are the only methods being widely used to make plastics tools.

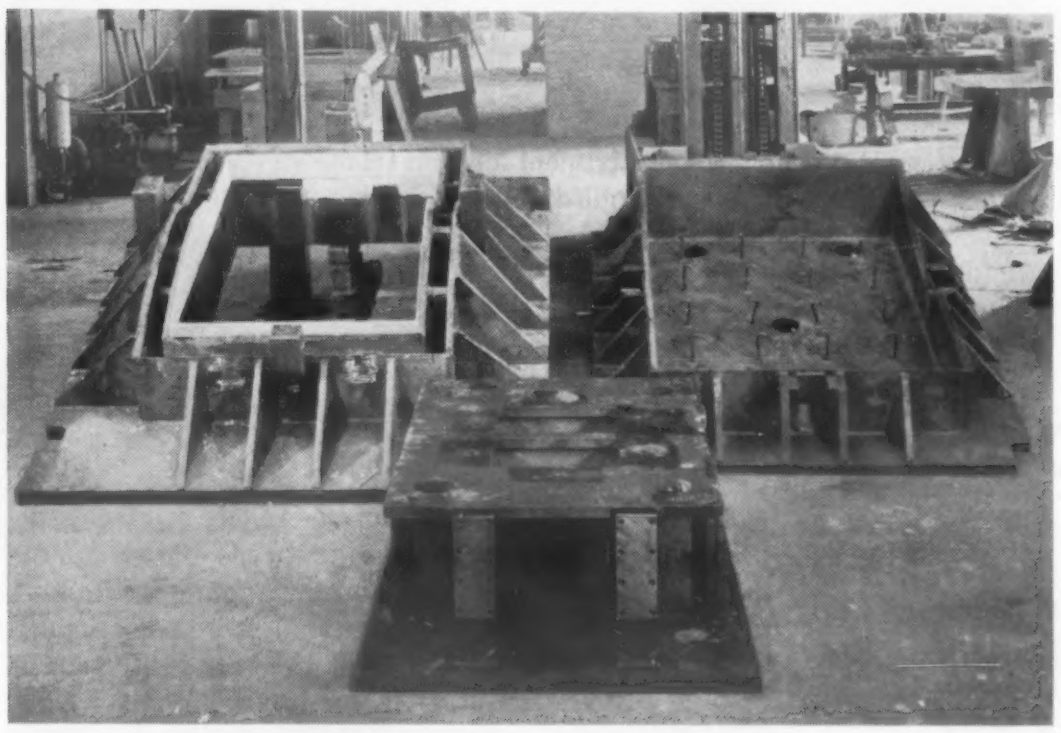
The major advantage in casting a tool lies in the relative simplicity and speed of the operation. Laminating, though generally slower and more costly, multiplies the strength and toughness of the cured tool. By combining a laminated face with a cast core, the advantages of both techniques are gained. The surface of the tool is tough and strong, while the larger bulk area is filled rapidly with a cast material.

### Making the Mold

The mold for forming a plastics tool may be of wood, plaster, plastics or metal. In some cases the mold may be formed by the original pattern with the necessary build-up to contain the resin. The most common method of mold-making consists of taking a plaster "splash" from the




**By forming one die member against the other, die spotting, necessary with metal tools is eliminated.** *(Pratt & Whitney Aircraft Div. of United Aircraft Corp.)*



**These are typical weldments used to contain plastics draw dies. Weldment at right is for female member, bottom is for male punch, and at left is draw ring.** *(Creative Industries of Detroit, Plastic Tool Div.)*

pattern to form the mold. A plaster mold is generally more economical when only one tool is needed. It is usually destroyed when the tool is removed from the mold. When several identical tools are needed economy would probably dictate the use of a plastics mold which can be used repeatedly. An important point to remember is that the mold must contain whatever degree of accuracy is desired in the tool.

### Casting the Tool

Castings can be either open or closed type, depending on requirements of the individual tool. With the open type, a simple wooden build-up around the mold surface may be sufficient to hold the casting resin. The mold should be level, and all surfaces to be exposed to the resin should be carefully coated with parting compound. For closed type casting, a flask must be built up over the mold with properly placed gates and risers to ensure proper filling and exclusion of all air.

When casting phenolics, mixing containers should be of acid-resistant materials. When mixing epoxy resins proper ventilation should be provided to minimize the danger of dermatitis which may be caused by the toxic amine hardeners.

Curing techniques depend on the type of resin used. Epoxies may be cured at room temperature, though an oven-cure will improve mechanical properties. Generally, phenolic castings of 100 lb and under require a 150-200 F, 12- to 16-hr cure, while castings weighing over 100 lb, 200 F for 16 to 24 hr will suffice. For greatest dimensional control, some companies recommend a flat 24-hr cure cycle for larger castings. Curing for too short a time results in unstable castings, while excessive heat causes castings to boil and become porous. Curing directions issued by each resin supplier should be followed closely.

Since large unsupported thermosetting castings are relatively brittle, cast tools are generally contained in a metal weldment, minimizing dangers of fracture or cracking. Small radii or thin sections in the face of a tool may be reinforced by metal inserts. Inserts may be set in the tool as it is poured or added later by drilling out the plastics and bonding the insert with fresh material. Inserts should be designed to lock mechanically with the plastics. Wherever phenolics come in contact with metal, the metal must be carefully coated with a protective material such as an epoxide coating.

### Laminating the Tool

The importance of laminated structures lies in the increased strength and toughness provided by the reinforcement. According to one estimate, use of glass cloth reinforcement will increase the tensile strength of a plastics resin 4 to 8 times, improve flexural modulus 3 to 5 times, and

compressive strength 1½ to 2 times. Impact strength can be raised from about 1 to 15 or 20 ft-lb per in. of notch (Izod).

After preparation of the mold surface, the first step is usually the application of a plastics gel or surface coat about 1/16 in. thick. The usual purpose of this coat is to prevent the glass reinforcement from coming through the face of the tool. However, several types of surface coating materials are available with different properties for specific tool applications, i.e., hardness, resilience, and abrasion resistance. The coat should be allowed to gel to a tacky state before continuing with the laminating process. Any sharp corners in the mold face should be filled with a resin-chopped glass paste to form a fillet, allowing the glass cloth to mold tightly to contour. Laminating resin is then applied, followed by glass cloth and more laminating resin until the desired thickness is attained. Usually ½ to ⅝ in. is considered sufficient.

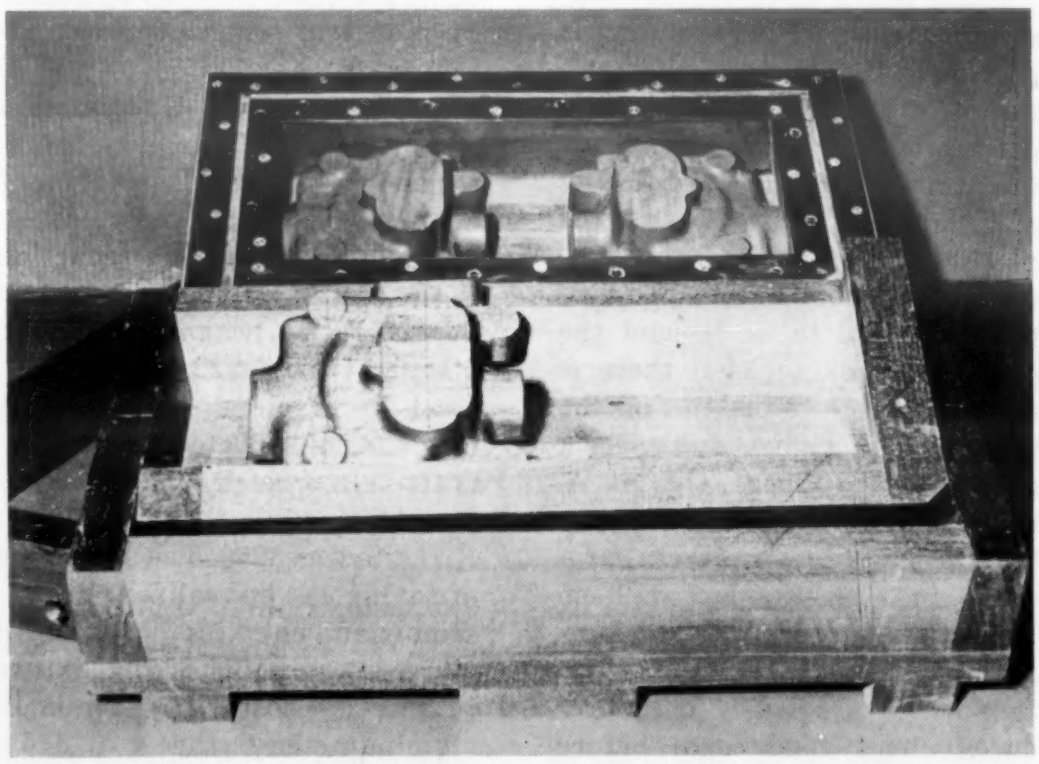
During the lay-up process all air voids between the laminates must be eliminated. Careful stippling of each layer of resin into the glass cloth should insure a good, homogenous structure. The success of the tool will depend to a great extent on the degree of success with which the air is eliminated and the glass cloth impregnated.

### Core Constructions

One of the most common tool constructions today, particularly for metal- and plastics-forming tools, employs a laminated face backed by a suitable core material. Core materials range from foamed phenolic with a compressive strength of around 500 psi, through filled casting resins, to cast iron, Kirksite and even concrete. Each of these constructions provides a tool with different characteristics. Another type of construction consists of a core material with a thin cast face. Some drop-hammer dies, for instance, use a Kirksite core faced with a resilient epoxy formulation. Variables to be considered in choosing the core material include forces which will operate on the tool, weight, any temperature limitations, and cost of fabricating.

Where epoxies are used in combination with another material, the epoxy area should be formed last to take advantage of its good adhesion. For example, when applying an epoxy laminate face to a foamed phenolic core, the laminate is laid up in the mold according to normal procedure and the core is foamed separately to under-size dimensions. The cured core is then fit into the mold over the cured laminate, and epoxy resin is poured between the two, bonding them.

Supporting structures for laminated tools such as checking and assembly fixtures, can be made with a variety of materials. For small simple tools the strength of the laminate itself may be sufficient. For larger more complex tools, paper-based phenolic or epoxy, or epoxy- or polyester-impregnated glass cloth tubing may provide the necessary stability and still offer the dividends of minimum weight of tool. Masonite, Formica, or a similar form of a structural plastic may be used to build up an egg-crate type of supporting structure. Choice of material is usually based on economic factors such as availability, price, etc. Where requirements for maximum structural rigidity over-ride weight considerations, a welded steel or cast iron structure can be used.



One developmental use for plastics is in core boxes such as this one for an exhaust manifold. Surface is cast in epoxy, with supporting structure of epoxy laminate. Edges of flask are reinforced with metal. *(Kish Resin, Inc.)*

### Tool Life

*Checking, Locating and Assembly Fixtures*—Most fixtures undergo little stress in actual service. The major limiting factor on tool life is rough handling in the shop. If treated properly, barring accident, this type of tool can last indefinitely. Usefulness of a fixture is more likely to be ended by design change rather than by its deterioration. However, careless handling usually means short tool life. Plastics, though a relatively tough material, cannot compete with metal in impact strength and durability.

*Metal-Forming Tools*—Die life can not be predicted at this time. It will depend on the material being formed and the draw characteristics. Limitations on gage of material that can be formed

generally run around 0.060 in. in cold rolled steel, 0.030 in. in stainless, and 0.080 in aluminum. Though there are instances of plastics draw dies turning out 100,000 steel parts, the general range is more likely to run somewhere under 50,000 parts. Most manufacturers say they don't know how many parts a die will produce because it is still in operation. Figures given for production to date may range around 10,000, 15,000 or 20,000 parts. More often they will fall in the hundreds.

The maximum life of stretch-press dies is difficult to determine because most aircraft manufacturers have found that the dies will last the length of production for one configuration, which may be several hundred parts. At the end of the lot the dies are still in good condition, but since the design has been changed the tool is of no further use.

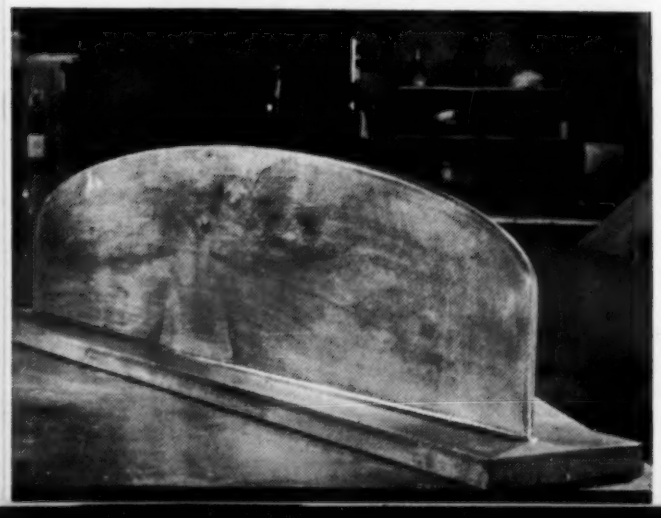
*Plastics-Forming Tools*—Tool life will depend on the temperatures and pressures used in each plastics-forming process. When contact molding with a room temperature cure, the mold may last virtually indefinitely. Where elevated temperatures are imposed the production runs will be limited.

Cast phenolic molds, when subjected to elevated temperatures over a long period of time, will dry out and eventually crack and disintegrate. Generally, with the temperatures used for plastics-forming (150-225 F), several hundred parts may be made before embrittlement and cracking becomes a limiting factor. Oven-cured epoxies have heat distortion points of around 300 F, but thermal cracking and elevated temperature creep impose limitations on tool life. Life of the tool can be increased by extending the cure cycle of the plastics being formed, allowing lower temperatures to be used. Polyesters have relatively good resistance to heat, but low pressures must be used, and their poor resistance to thermal cycling is a limiting factor.

One manufacturer defines limited production of plastics parts on plastics dies as less than 500 to 1000 pieces. He also states that there is no tooling plastics today which will withstand continuous temperatures of 200 F at pressures of 100 psi.

*Die Models and Prototypes*—Since use of these tools does not generally involve critical stresses, they usually last as long as they are needed. They are used mainly during fabrication of metal tooling and design development which is a relatively short period. They may then be stored for future use, but generally storage would not be detrimental to the tool.

Cast phenolic mold is used at East Coast Aeronautics to form polyester-glass laminate wing tip. *(Marblette Corp.)*



## Developmental Tools

Besides these standard categories of tools, there are other manufacturing areas where plastics are being tried for developmental tools. The foundry is probably the most important. Patterns, core boxes and even pattern dies for wax patterns for investment casting are being made in plastics. The use of plastics for loose patterns, matchplates or cope and drag plates is said to be beyond the experimental stage, but there is still resistance to plastics on the part of foundrymen due to lack of knowledge about the materials. In one core box application, 51,710 plaster cores were produced in a plastics box with no indication of wear or deterioration of the box. Dental stone core boxes previously used produced about 1500 cores before loss of dimensional accuracy. One company found that a plastics die for forming wax patterns for investment casting cost $200, while a soft metal die would have cost about $2000.

These are just some of the uses to which plastics have been put in tooling. As many in the industry point out, the use of plastics is limited only by the imagination of the tooling engineer. Plastics are not an answer to every problem. They are materials with unique properties which can provide substantial savings when applied objectively and intelligently with a realistic understanding of their characteristics.

## Economics of Plastics Tooling

One of the major effects plastics tooling may have on the industrial economy is in the area of product design. When planning the production of any product, amortization of tooling costs is a prime consideration. If initial tooling costs are high, the production quantity must be large to pay for the tooling. By reducing tooling costs, amortization may be completed over a shorter production run, allowing more frequent design changes. The cost of a plastics tool may be amortized over several hundred or a thousand parts, whereas with metal tools design of the same part may have to be frozen over several thousand or a million parts.

Though some plastic tools may cost more than their metal counterparts, generally a reduction of 30 to 70% can be expected. An example of an average reduction is the cost of a die used to stamp metal station wagon roofs. In plastics it cost $22,000 while in steel the same die would have cost $38,000. The cost of an aircraft skin stretch die in plastics was $152, while the same die in Kirksite was $256. The same type of saving can be realized with assembly and checking fixtures. An aircraft canopy checking fixture in plastics cost $331, while in aluminum the fixture cost $854. Two check blocks cost $1.20 in plastics, and $8.20 in steel and plaster. In the plastics-forming

## Why Use—

### EPOXIES

#### Advantages

Versatile — Available both as laminating or casting resin. Casting resin may be filled with variety of materials.

High Dimensional Stability—Provides rigid, durable tools with superior physical properties.

Low Shrinkage — Permits the highest degree of dimensional accuracy in the tool.

Excellent Adhesion — Ensures good bonds between resin and inserts, reinforcement, filler materials and cured plastics for repair.

Good Wettability—Aids complete and consistent impregnation of cloth reinforcing with resin.

Room Temperature Cure—Removes size and shape limitations imposed by oven capacities.

Non-Reactive with Other Materials—Metallic inserts may be cast-in and base plates attached without prior protective treatment. Allows use of variety of filler materials.

#### Limitations

Relatively Poor Temperature Resistance—Maximum heat distortion point for room temperature cured epoxies is 180 to 200 F; for oven-cured, 300 to 350 F.

Toxicity—Amine hardeners are toxic and may cause dermatitis if user is allergic.

High Cost—Basic resin costs $0.80 per lb.

### POLYESTERS

#### Advantages

Low Cost — When considering resin cost alone, the polyesters are the cheapest, the cost of the pure resin being about $0.35 per lb. Glass reinforcing raises cost of laminates.

Good Mechanical Properties—Cured laminates provide tools with good durability and strength.

Good Heat Resistance — Have heat distortion points of around 250 to 300 F. Resins available that withstand up to 500 F.

Good Wettability—Aids complete and consistent impregnation of cloth reinforcing with resin.

Non-Reactive with Other Materials—Metallic inserts may be cast-in and base plates attached without prior protective treatment.

#### Limitations

Laminating Only—Though one company developed a method for casting polyesters and overcoming high shrinkage, method is not widely employed and polyesters are used mainly in laminated form.

High Shrinkage — Volumetric shrinkage, averaging between 6 and 10%, prohibits forming highly accurate tools.

Oven-Cure Required — Though polyesters can be cured at room temperatures, optimum mechanical properties are not obtained. Curing temperatures of 200 to 250 F are generally required for tools.

### PHENOLICS

#### Advantages

High Temperature Resistance—Phenolics have highest heat distortion point: 300 F for continuous use, 400 F for short periods.

Ease of Casting—Phenolics can be cast relatively easily and cheaply to desired tool shape.

Low Shrinkage—By using filler materials, shrinkage can be reduced to a relatively low value.

Low Cost—Phenolics can form lowest cost tools, since casting resins ready for use sell for as low as $0.35 to $0.40 per lb.

Good Mechanical Properties — Cast phenolic tools possess sufficient compressive and tensile strengths for most applications.

Foams Available—Are available for use in cores for tools.

#### Limitations

Castings Only — Phenolic castings are the only form generally employed for plastics tooling.

Brittle — Unsupported Castings are relatively brittle.

Reactive with Other Materials—The acid catalyst employed will attack unprotected metal, and limits fillers to asbestos and similar materials.

Oven-Cure Required — Though some phenolics can be cured at room temperature, reports indicate lower physicals and increased shrinkage. Generally, cured at 150 to 200 F for 2 to 24 hr.

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field, a mold for forming an aircraft radome cost $6197 for the first mold, and since no additional tooling was necessary, $1237 for the second. In controlled quality cast iron, the same mold would have cost $20,480 for the first, and $9920 for the second.

The variable cost factors involved in producing a plastics tool will differ with each tool. For relatively simple shapes where accuracy is not critical, the cost of the resins may be the largest item. In the majority of cases, however, the cost of fabricating the pattern or mold will be of primary concern. As was mentioned before, the accuracy desired in the tool must be built into the pattern or mold. Pattern-making is highly skilled, expensive labor.

How important is the present price differential between the tooling plastics? When considering the large savings possible through the use of plastics tools, the comparatively slight difference in price should not be weighed too heavily. Cost of materials will generally amount to 20-25% of total tool cost. Of course, where a less expensive material will serve the tooling needs, it should be selected, but only where it will serve just as well as the more expensive. The materials should be selected on their engineering properties and the service conditions under which the tool must work.

A last word should be inserted here regarding labor costs. There has been much talk about the inexpensive labor used for plastics tool fabrication. It is true that a plastics fabricator is usually paid less than a steel tool maker. However, when accurate, high quality tools are desired, competent labor must be used. The workers must be careful, conscientious and must be guided by highly skilled supervision.


#### Acknowledgment

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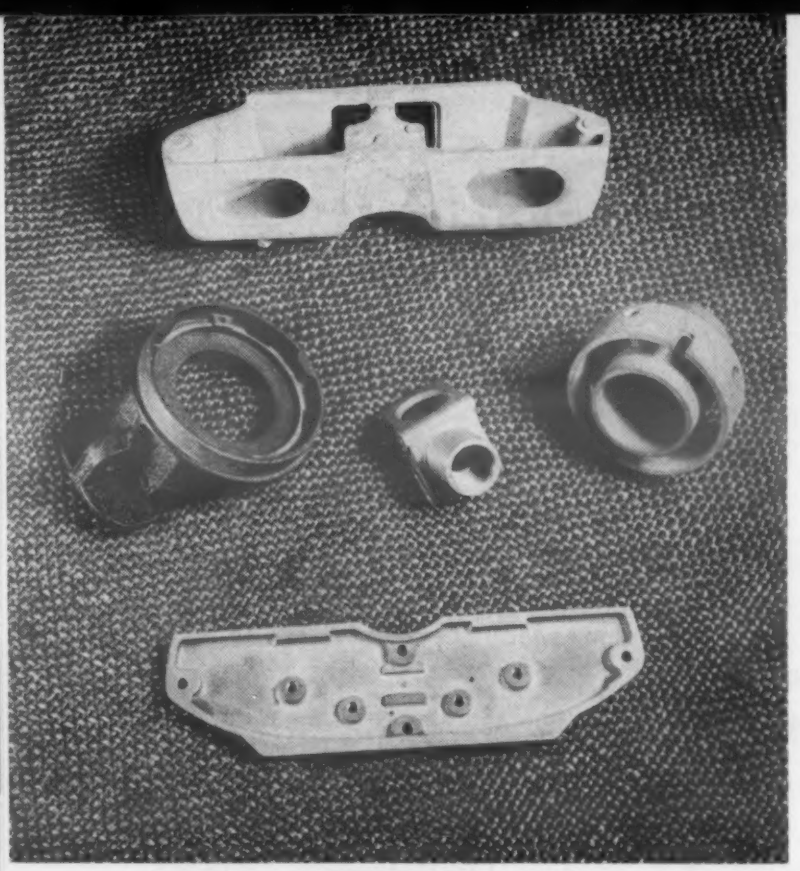
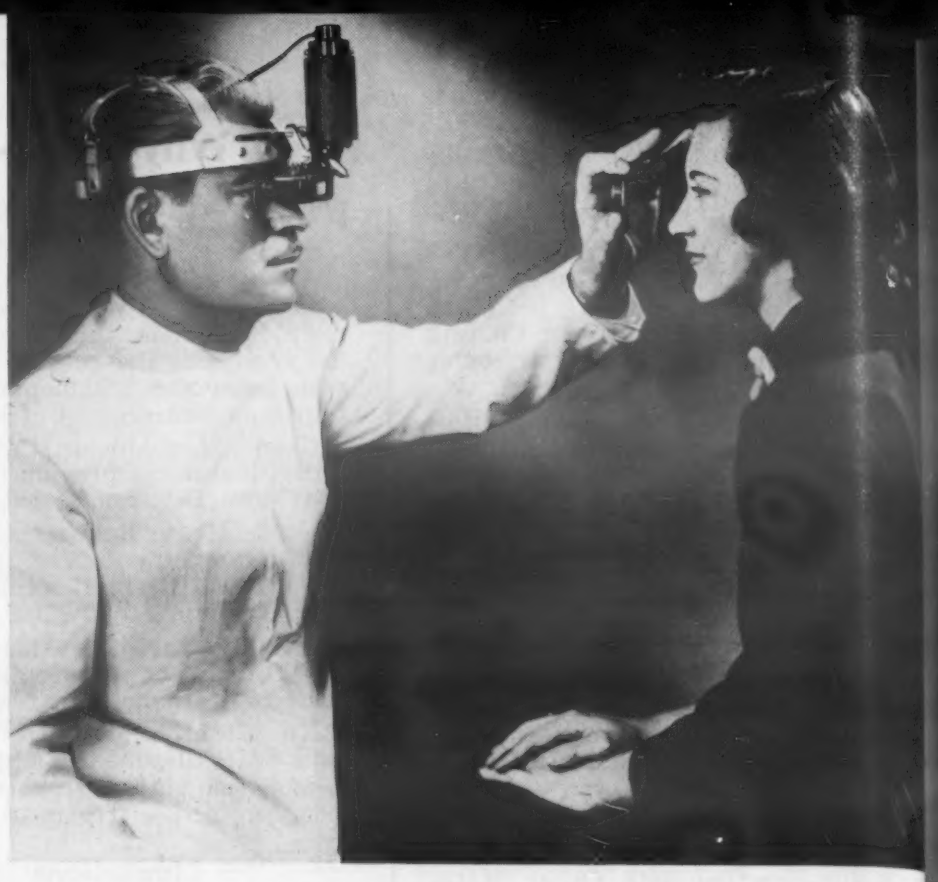
Hercules Powder Co.
Kish Resin, Inc.
Lunn Laminates, Inc.
The Marblette Corp.
Modern Pattern Work
Owens-Corning Fiberglas Corp.
Pittsburgh Plate Glass Co.
Pratt & Whitney Aircraft, Div., United Aircraft Corp.
Ren-ite Plastics, Inc.
Republic Aviation Corp.
Rezolin, Inc.
Shell Chemical Corp.
Lawrence Wittman & Co.





**Ophthalmoscope** utilizing magnesium investment castings (left), together with plastics, makes long hours of eye examination and surgery more comfortable for the doctor. (*American Optical Co.*)

## In These Applications

# Magnesium Investment Castings

■ THE HIGH strength-weight ratio of magnesium and the economies of investment casting make a good combination for light-weight instrument parts.

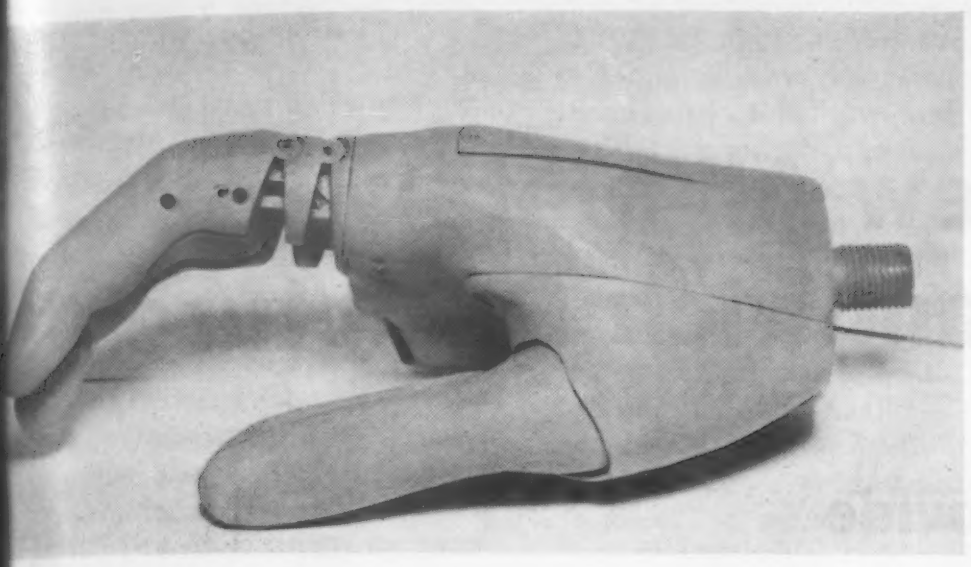
Most light-weight investment castings are made from one of two aluminum-silicon alloys: heat treatable 356 or non-heat treatable 43. The only magnesium alloy suitable for investment casting is Dowmetal C (ASTM AZ92)—a heat treatable material containing 9 aluminum, 2 zinc and 0.1% manganese.

Compared with alloy 356, the most commonly used aluminum alloy for investment castings, Dowmetal C is slightly less castable and not quite as suitable for serrations and similar fine details. It is also less pressure-tight, less shock-resistant, less corrosion-resistant and considerably more difficult to handle in the foundry. On the other hand, Dowmetal C is the equal of alloy 356 in tensile strength in both the as-cast and the heat-treated conditions. Therefore, a cast section of Dowmetal C can often be substituted for a cast section of alloy 356 without any increase in thickness and with a reduction in weight of about 32%. For applications where such weight reductions are important, magnesium investment castings may be preferred to aluminum despite certain inferior properties.

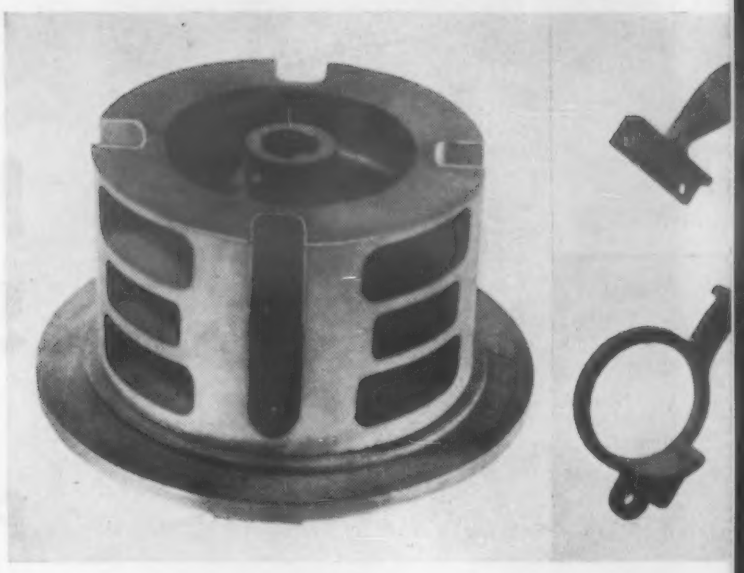
Where light weight is important, investment casting is often particularly desirable because thinner sections can be produced than can be forged or cast by most other processes. Otherwise, investment casting offers the same advantages for magnesium that it offers for all other metals: 1) intricate shapes that cannot be made in one piece by forging or any other method, 2) high dimensional accuracy resulting in reduction or elimination of machining operations, and 3) short run parts less expensive than forgings requiring expensive steel dies.

Although aluminum investment castings are fairly common, the bulk of magnesium investment castings can presently be found in two general areas of application: aircraft instruments and instruments supported by human beings during use, such as optical instruments. Even in small parts, magnesium plays an important role in the aircraft engineer's battle to cut dead weight and increase "payload," especially in military planes and missiles. In other instruments, light weight is important chiefly when it makes a product easier to use and therefore increases its attractiveness and saleability. Typical instrument parts include housings, covers, brackets, bearing sleeves, supports, elbows, valves and impellers.

At present, only one company —Arwood Precision Casting Corp.—is known to be a regular producer of magnesium investment castings in commercial



**Prosthetic Hand** made of magnesium investment castings to keep total weight below 12 oz is now undergoing wearer tests. Assembly is shown with a protective coating as shown here. Sometimes an additional cosmetic covering is applied to simulate the natural appearance of the skin. (*Walter Reed Army Medical Center*)



**Lightest and Heaviest** magnesium investment castings now in use are about the size of these parts (shown about one-half actual size) for aircraft instruments. Weight ranges from 0.08 to 7 oz. (*Arwood Precision Casting Corp.*)

# Save Weight

**by John B. Campbell,** *Associate Editor, Materials & Methods*

quantities. Arwood's magnesium facilities are located in its Tilton, N. H., plant. All parts shown on these pages were cast by that company.

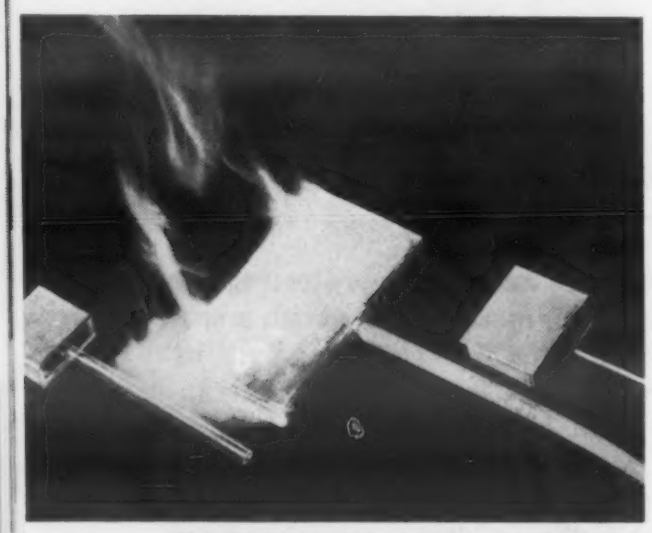
Magnesium investment castings, as-cast, average about 21,000 psi in tensile strength and E 60 in Rockwell hardness. Solution-treated 20 hr at 760 F and aged 14 hr at 420 F, they average about 36,000 psi in tensile strength and F 80 in Rockwell hardness. Lack of toughness, reflected in low elongation and impact strength, makes them unsuitable for parts subjected to shock or appreciable stress. Although thin sections can generally be cast pressure-tight, porosity in thick sections is sufficient so that, unless impregnated, they cannot be used in parts that must be pressure-tight.

In general, any part that can be investment-cast in aluminum can also be produced in magnesium. The maximum section that can be produced is ¾ in. Walls as thin as 0.030 in. can be cast in small areas. Minimum hole diameter, where depth does not exceed diameter, is 0.020 in. Minimum dimensional tolerances as low as ±0.002 in. can be held on some small parts. Surface roughness is the same as for other investment-cast metals (125 micro-in. rms without special finishing.) Parts produced so far have ranged in weight from 0.08 to 7 oz.

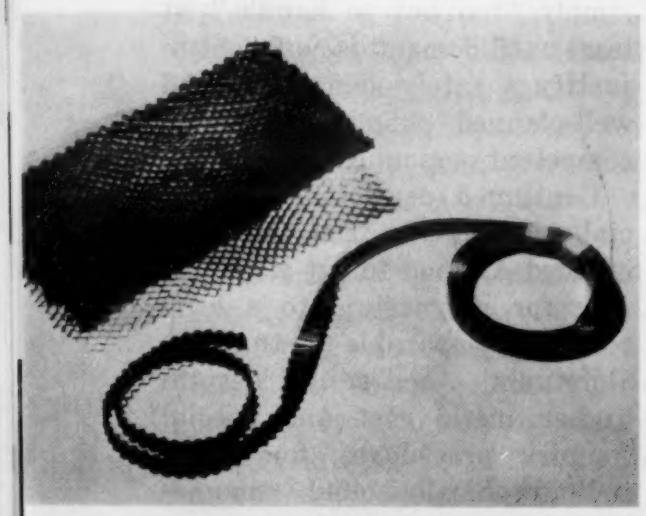
The limited availability of magnesium investment castings is due not only to the relatively narrow scope of their present applications but also to the difficulties encountered in handling magnesium in the foundry. Molten magnesium is extremely reactive. It reacts with the mold unless a special inhibitor is incorporated in the investment material. It oxidizes readily and burns with explosive violence. Contact with moisture must also be avoided. Dangerous oxidation can be avoided by protecting the molten metal surface with a special flux or atmosphere, by proper gating to prevent entrapment of air in the mold and, in general, by careful foundry procedures. The risks involved in handling molten magnesium have undoubtedly been over-emphasized in many cases. Rightly or wrongly, however, most foundries feel that magnesium is simply "too hot to handle," at least until demand is sufficient to justify a safely segregated and well-planned shop staffed with competent personnel.

Continued development, especially during the past year, has enabled Arwood to cut its reject rate for magnesium to a level roughly comparable to that for aluminum. As a result, despite higher metal cost and special foundry procedures, fine-grain, radiographically-sound magnesium investment castings do not cost significantly more than aluminum investment castings.

Total length of braze fillet exceeds 1½ miles in this jet tail-cone shroud made of all-metal sandwich.



Sandwich with porous metal facings could be used for sweat cooling and anti-icing. Smoke permeating material demonstrates porous metal face.



Core material is generally made of strip stock, shaped and joined by various methods.

# New All-Metal Sandwich Structures

## Provide

- *High temperature resistance up to 1500 F*
- *High strength-to-weight ratio*
- *Good sound and heat insulation*

## Could Be Used for

*Aircraft skins and parts*
*Compressor parts and casings*
*Shock mounts*
*Fluid heat exchangers*
*Fire walls*
*Missile skins*
*Acoustical insulation*
*Engine compartments*
*Anti-icing structures*

**by John V. Long,** *Director of Research,*

**and George D. Cremer,** *Senior Staff Engineer, Solar Aircraft Co.*

■ TEMPERATURES ARE INCREASING both inside and outside of aircraft and missiles. Inside because engines operating at higher temperatures are necessary to achieve the higher speeds. On the outside, higher speeds are raising skin temperatures due to air friction and compression.

Unfortunately, strength properties of light metals fall off sharply as temperatures increase. Though titanium shows promise for applications up to 800 or 900 F, much developmental work on production and fabrication must still be done. Stainless steels and other high alloys show the most promise for high temperature applications because of high strength and oxidation resistance. However, their weight is a detriment in aircraft use. All-metal sandwich structures, joined metallurgically, combine the strength and oxidation resistance of these ma-

terials with a substantial reduction in unit weight.

### Honeycomb Structures and Materials

Honeycomb sandwich structures may be classed as anisotropic, integrated sheet metal assemblies. Foil-thin ribbon arranged in a honeycomb pattern comprise the core which is sandwiched between facings or skins. The facings are the prime load-bearing members, and by proper design, complete surface stabilization permits ultimate compression strengths to be realized even in the thinnest gage faces. The core provides essentially continuous support to prevent buckling under compression while at the same time transmitting shear stresses. The resulting structure can provide exceptionally high strength-to-weight ratios, excellent stiffness, vibration dampening, and thermal and acoustical insulation.

The high temperature alloys used at Solar include AISI 321, Armco 17-7PH, Inconel X, Multimet and Haynes Alloy 25 (L-605). Thickness of facings or skins usually ranges from 0.010 to 0.030 in., while core stock runs from 0.001 to 0.010 in. An accompanying chart presents comparative curves for a number of alloys, showing yield strength per unit weight versus temperature. Below about 900 F the superiority of 17-7PH is evident, while higher temperatures indicate the use of Inconel X, and extreme temperatures require L-605.

### Core Construction

Steel and high alloy sandwich core is usually manufactured in square, hexagonal or wave-shaped cell types, though numerous other core designs have been produced. While the square cell type core is manufactured in the open condition it may be collapsed for grinding or machining operations. In an egg-crate type core the longitudinal and transverse ribbons are slotted half way and assembled slot to slot. This type of construction completely resists bending along longitudinal and transverse axes.

None of the core structures mentioned thus far are well suited for sandwich parts having severe two or three dimensional curvatures. Square cell cores having narrow node bonds compared to node width can accommodate slight bending providing the radius is ample or the core height relatively shallow. Other cores, designed for flexibility, include a finely corrugated core assembled in square-cell fashion and a Multiwave type which is stabilized by longitudinal ribbons. The Sinecell construction permits two and three dimensional curvatures of a lesser magnitude.

Adhesive bonding and resistance welding are the two chief methods used in assembling ribbons into honeycomb cores. Other techniques include wire stitching, eyeletting, and slotting. A process starting with a single sheet of metal rather than a ribbon makes cores by a method similar to that employed in manufacturing expanded metal. Being open at the nodes, this structure holds promise for applications where fluid flow and heat transfer between skins and core are desired.

Since brazing tolerances between facings and core must be held within ±0.002 in., machining a contour on the core presents a critical problem. The core may be frozen in ice and the necessary milling operations carried out at sub-freezing temperatures, or a plaster of paris composition can be used to hold the core for contouring. Electrical disintegration is another technique which may prove practicable in production.

**TYPICAL PHYSICAL PROPERTIES***

| Properties | 75 F | 800 F | 1000 F |
|---|---|---|---|
| Tensile Strength (face after brazing), psi | 175,000 | 115,000 | 60,000 |
| Edge Compression, psi | 180,000 | 130,000 | 80,000 |
| Flat Compression, psi | 4000. | 2600 | 1300 |
| Maximum Core Shear, psi | 500 | 400 | 350 |

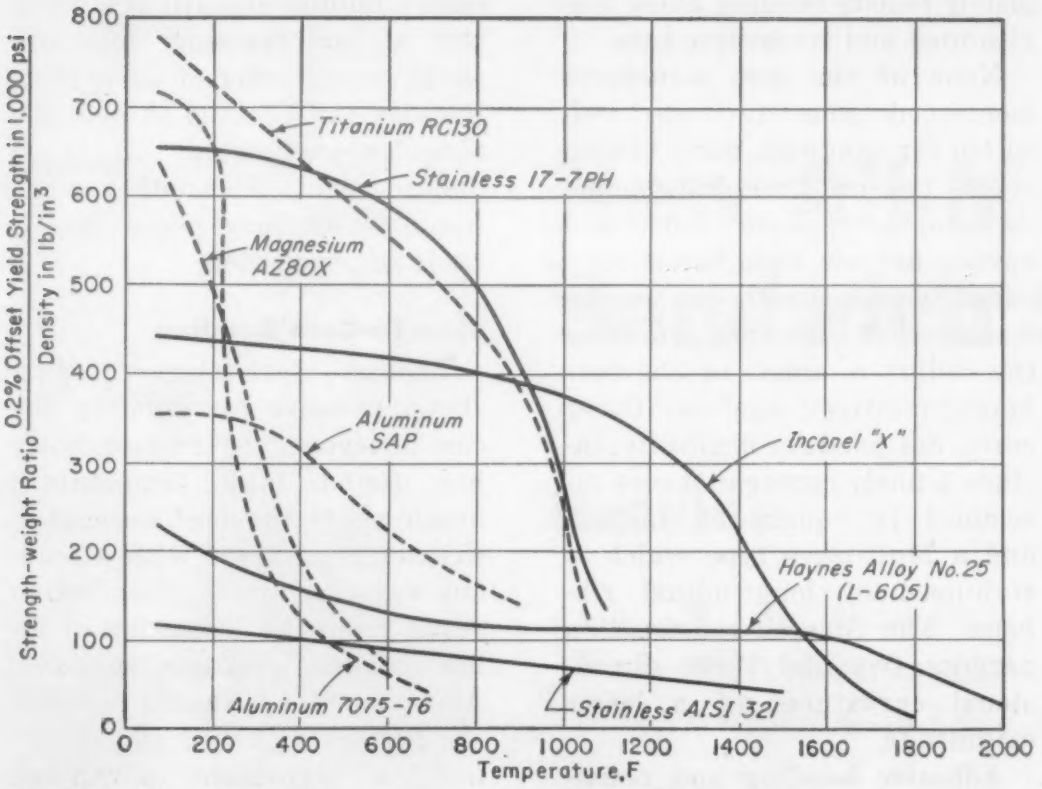
** Heat treated panel, ½ in. thick; 17-7PH alloy used; 0.002-in. gage, ¼-in. square cell core; 0.015-in. gage faces.*

### Skin-To-Core Bonding

Though resistance welding shows promise for bonding the core honeycomb to the face, Solar has found high temperature brazing to be the most successful. Greater bond areas with attendant uniform stress distribution result from the formation of fillets between mating surfaces. Also, the skins spanning each cell are further stiffened and stabilized, a significant advantage when using relatively thin skins. The brazing alloy also infiltrates the node laps, sharply improving their column and shear properties. When excess braze metal is used sandwich strengths improve, but weight economy suffers.

The importance of the procedure in brazing the core to the faces of all-metal sandwich structures should not be minimized since even minor repairs to a brazed panel are frequently prohibitive. Metal surfaces should be cleaned, degreased and occasionally pickled. At Solar, a proprietary high temperature brazing alloy is then applied as granular powder directly to the core nodes and held in place by a volatile, plastic solution. Small amounts of special fluxes may also be applied. Preliminary experiments show the feasibility of applying the braze mixture in a plastic film or tape. The film is placed between core and sheet, and since the brazing alloy flows freely upon heating, only one sheet of film is required to braze both faces. Brazing is carried out at temperatures of around 1900 F.

The most significant single factor in assuring optimum braze integrity is maintenance of intimate contact between the components throughout the brazing




Strength-to-weight ratio vs temperature for various alloys.

operation. In many cases this requirement for intimate contact is coupled with the necessity for aerodynamic smoothness on exterior areas, a difficult combination particularly at the high brazing temperatures employed. Though curved panels are frequently easier to fabricate, Solar has established standards on flat panels as large as 24 by 60 in.

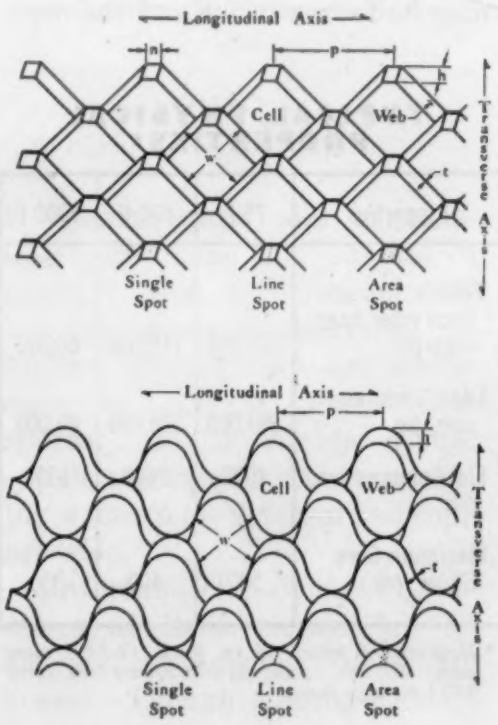
Non-destructive testing standards have not been established for all-metal sandwich structures. However, both x-ray and sonic methods seem promising since the existence of braze fillets is evidence that wetting, capillary flow and resulting metallurgical bonding has taken place.

## Physical Properties

While physical property data for design engineering of metallic honeycomb structures are meager, investigations are now underway at such institutions as Forest Products Lab, and the U.S. Department of Agriculture, sponsored by Wright Air Development Center. An accompanying table lists typical strength values for one specific structure at various temperatures.

Compressive strength of the sandwich is greatly dependent upon cell design. Through proper choice of cell configuration and material, values as high as 4000 psi have been realized in 2 mil, ¼-in. cell core. Tests up to 1650 F have shown high temperature brazed construction to have excellent integrity. Creep properties of the materials are superior to adhesive bonded sandwich at all temperatures. Impact strength is improved. Damage inflicted by a 20-mm projectile is localized and skin peeling halted at the cell wall joint.

Two honeycomb constructions. Top, square cell; bottom, Sinecell. Key: h-web height; n-node width; p-pitch; t-web thickness; w-cell width.




## Applications

These materials are so new that no applications have yet reached the production stage, though, there are a number of interesting applications under development. The largest commercial all-metal honeycomb sandwich that has been flight tested is a stand-off self-supporting afterburner shroud around a jet tail-pipe. Temperatures in the tail-pipe reach over 2000 F, indicating actual sandwich skin temperatures of 750 to 900 F. Eight curved panels were assembled to form split halves of a tube 5 ft long by 2 ft in diameter. The panels were constructed of 0.0026-in. gage AISI 321 alloy in both core and face. Weight of the brazing metal used comprised about 20% of the sandwich weight, exclusive of attachments. Over 1½ miles of braze fillet were used in the overall shroud.

Refined fabricating techniques have made possible the production of sandwich panels with porous metal facings. Such constructions could be used where fluid flow through the skin is necessary for heating or cooling purposes, such as in sweat cooling, anti-icing, aerodynamic bleed and boundary layer control.

By various methods, channels can be formed through the core material to accommodate fluid flow for heat exchanger applications. Shaped sandwich structures can be fabricated by contouring the face of the core before assembly, or stretch forming the panels after brazing. Possible applications of alumina-filled panels as rocket blast shields are indicated by recent tests. Damage to the panels is localized to the melted area, with no cracking or spalling in adjacent areas. Improved shock and erosion resistance is expected by using a special graphite filling in place of the refractory alumina.

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*Adapted from a paper presented at the Aeronautic Meeting of the Society of Automotive Engineers, October, 1954.*

# Materials at Work

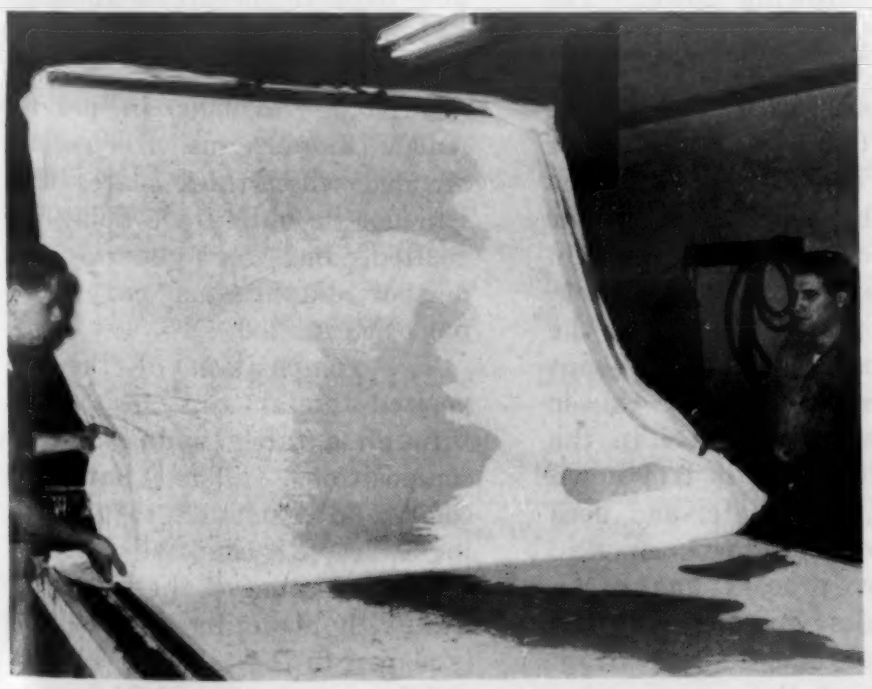
*New and old materials in unusual applications*

## Casting Rubber Relief Maps

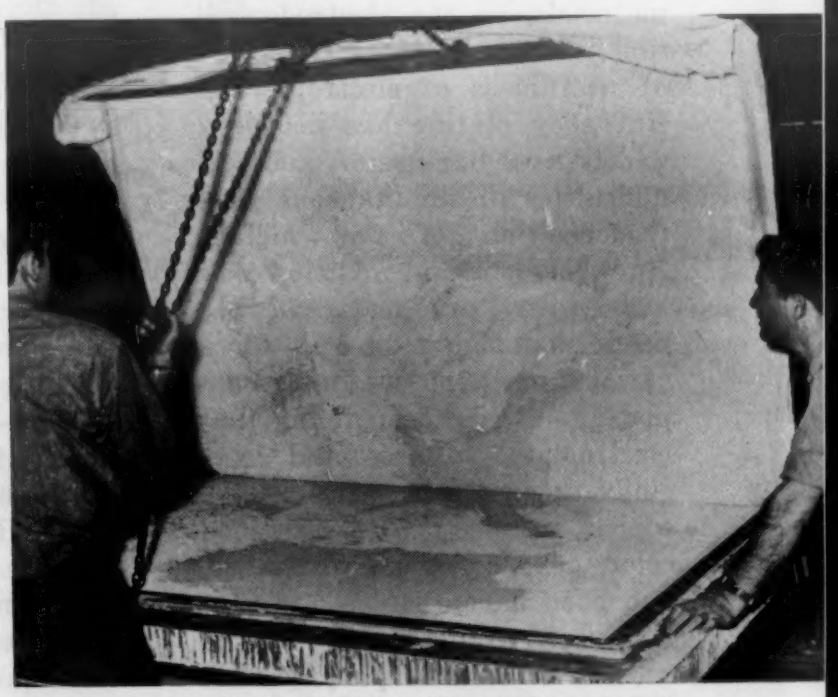
A polysulfide liquid polymer, produced by the Thiokol Chemical Corp. is being used to cast accurate relief maps for the Air Corps. The cold-setting compound is said to cure with negligible shrinkage and does not require pressure forming. Dimensions on relief features can be held to tolerances of ± 0.005 in., and the cured maps can be rolled for storage. They are being produced by Aero Service Corp.

**1.** The catalyzed liquid polymer is poured over plaster to form the negative flexible mold.

**2.** After leveling, glass fiber cloth is laid over the back of the mold . . .



**3.** and the negative mold is stripped from the plaster.



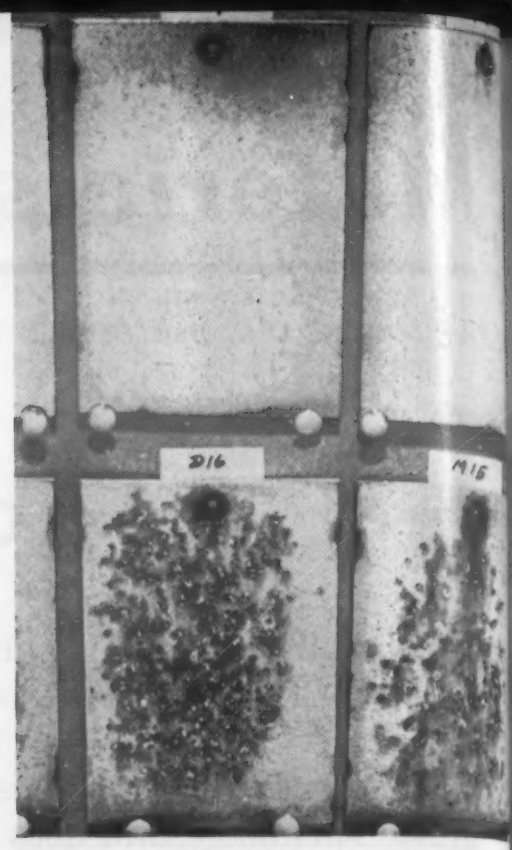
**4.** After spraying negative with parting agent, process is repeated and positive flexible relief map is stripped from mold.

**Excellent bearing properties**

. . . are realized with 80-20 bronze alloy plating on these pump parts produced by Denison Engineering Co.

**Maximum solderability**

. . . for these glass-to-metal seals is obtained with bronze plating at Fusite Corp. Caps are plated with both bronze alloy and tin.




**Better corrosion resistance**

. . . achieved on steel plated with bronze (1 mil), bright nickel (0.2 mil) and chromium (top) compared to bright nickel and chromium.

## . . . obtained with

# Bronze Plating

**by Kenneth Rose,** *Mid-Western Editor, Materials & Methods*

■ JUST AS the alloying of metals makes possible a greater range of properties in the resulting materials, so the electrodeposition of alloys widens the scope of usefulness of electroplating. But alloy plating has not been widely used because of technical difficulties in simultaneous electrodeposition of two metals. However, a recent addition that has proved practical, and has been adopted by industry for a variety of purposes is bronze plating. It has been found that electroplated bronzes, and especially those of about 80 to 95% copper, balance tin, possess good color, good corrosion resistance, and good hardness.

Largely contributing to the success of bronze plating is a new pyrophosphate bath which permits rapid deposition of an alloy uniform in composition, gives an easily buffed plate, and has good throwing power. The new bath, developed at Battelle Memorial Institute and covered by patents held by City Auto Stamping Co., Toledo, makes use of copper cyanide and stannous pyrophosphate instead of copper cyanide-sodium stannate as in the earlier speculum plating. Speculum plating, in which the alloy deposited contains about 50-60% copper, balance tin, is more difficult to control in the old stannate bath, is laid down as a hard, dull plate, and uses separate copper and tin anodes.

The new process has given good results commercially in both barrel and tank plating. Cost is about the same as for bright nickel plating. With a cathode current density in the range of 20 to 70 amp per sq ft and bath temperature at about 140 to 180 F, the plate is laid down rapidly at the rate of about 0.002 to 0.005 in. per hr. Anode diaphragms are recommended when thick plates that will not be buffed are being deposited, but for general use, neither diaphragms nor anode bags are needed.

The composition of the deposited metal can be varied through a fairly wide range of compositions. The hardness, color, and resistance to tarnishing vary with composition. The change of some of these properties with changing composition is shown in the table.

Alloys up to the 80-20 bronze

can be plated directly onto steel, zinc die castings, brass, and lead alloys, after the undersurface has been cleaned by conventional methods. Compositions higher in tin, such as speculum metal, adhere better if a lower-tin bronze plate is first laid down as an undercoat.

Levelling power, the ability to fill surface irregularities, seems to be associated with tin content. The 60% copper speculum and the 80% copper bronze possess good levelling power, but the 90% copper alloy shows little of this property. A plate of 93% copper, 7% tin shows good bearing properties.

### Corrosion Resistance

The alloy plate showed up well in corrosion tests when used as an underplate and also in outdoor exposure tests in several test locations. ASTM corrosion tests made by Battelle Memorial Institute gave comparative ratings to steel panels using several types of underplate and chromium plate. After 72 hr in the standard salt spray, steel panels with 0.0005 in. bronze and 0.00002 in. chromium plate showed scarcely any rust spots, while steel panels plated with 0.001 in. bright nickel and 0.00002 in. chromium showed many rust spots after only 48 hr exposure. Speculum plate 0.001 in. thick, and without chromium overplate, gave about the same protection as the bronze-chromium plates; and panels with 0.0007 in. copper plus chromium, and panels with 0.0007 in. copper plus 0.00015 in. nickel plus chromium were inferior to the speculum plate and to the nickel-and-chromium plates.

Tests with the acetic acid-modified salt spray, considered to be about three times as severe as the standard salt spray, indicated that bronze-nickel-chromium plates were superior in corrosion resistance to the copper - nickel - chromium plates. Bumper guards plated with the copper-nickel-chromium combination and tested in the modified salt spray showed from two to three times as many rust spots as the bumpers with bronze-nickel-chromium plate. The 80-20 bronze alloy gave better protection than the 90-10 type as an underplate.

### Applications

Here are a few interesting applications where bronze plating is being used to advantage.

The glass-to-metal seals produced by Fusite Corp., Cincinnati, for refrigerators and appliances are made of thin gage steel. In order to run the pins through the caps while keeping them electrically insulated from the cap itself, glass pellets are placed inside the perforations through the cap and the pins are embedded in the glass as it is fused. The steel is bronze plated to provide protection against corrosion. After bronze plating the seals are tin-plated.

Zinc die castings are given a bronze plating 0.0007 to 0.0008 in. thick as a base for chromium plating. The plate is here used for its decorative effect with the underplate of bronze providing both a low-cost base for the chromium and good resistance to weathering.

The original patents obtained by City Auto Stamping Co. for a bronze plate were in part for its use as a stop-off in surface hardening. The present bronze plate continues to be important as a stop-off for nitriding in industry.

A foundry producing an expensive casting in aluminum bronze finds that castings are occasionally machined a few thousandths undersize over one of the diameters. As the castings are worth a considerable sum each, the company wishes to salvage them. Present practice is to plate a 90-10 bronze onto the undersize diameter, building it up to a depth of as much as 0.25 in., then remachining.

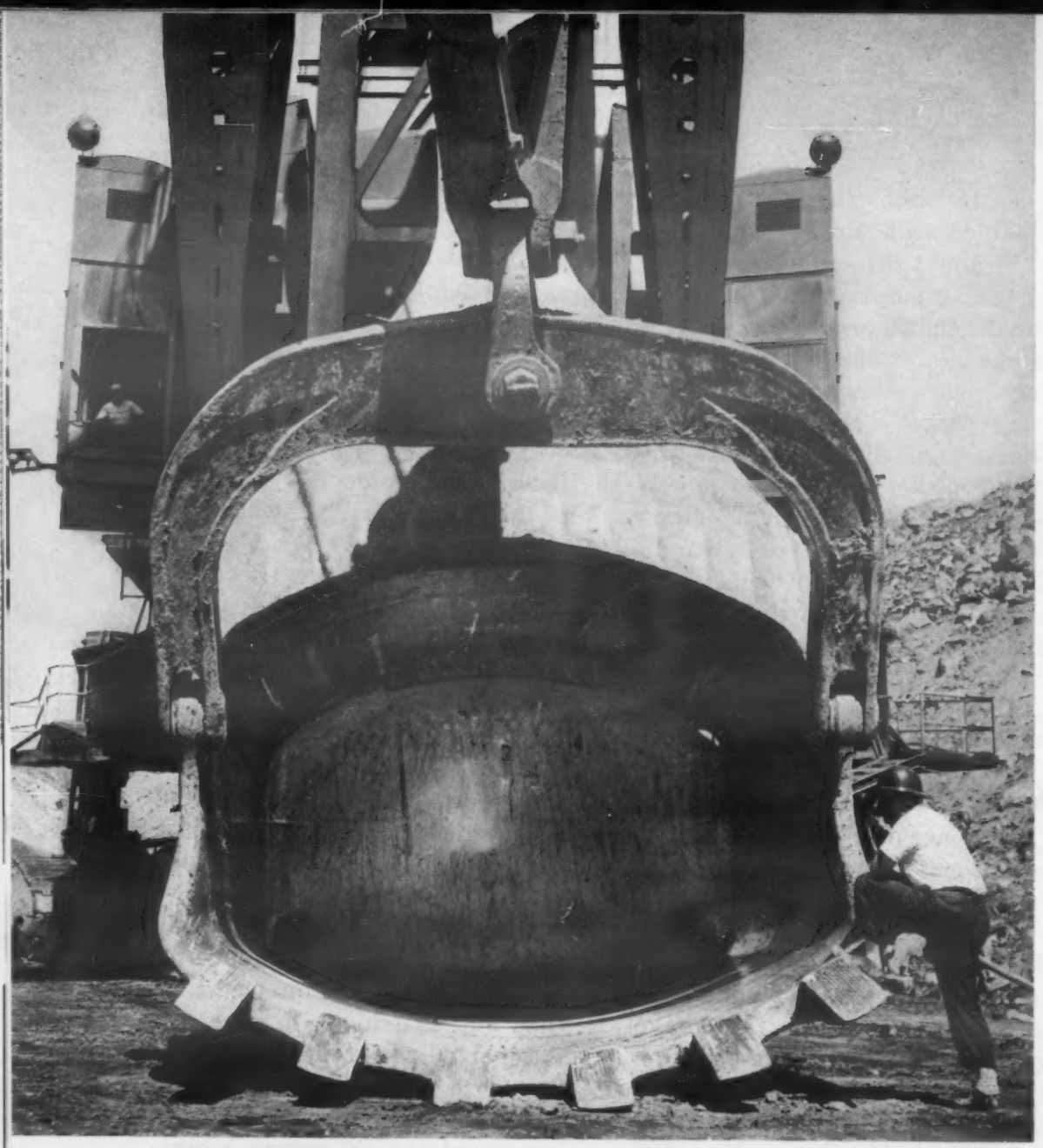
Bronze plate on a steel base forms an excellent composite bearing, capable of carrying unit loads of the order of 7000 psi. Denison Engineering Co., Columbus, is using bearings of this type, and also bearings made by plating the bronze onto cast iron caps and housings. Service life is reported as excellent.

Bronze door hinges are made with a steel pintle which is bronze plated to secure a uniform appearance. The same procedure is used with brass hardware, which is bronze-plated to improve its appearance. Another manufacturer of hardware, bronze plates some of the steel items in his line to make them uniform in appearance with the remaining items in the line.

The new process is receiving the attention of producers of chromium plated trim. Such pieces are ordinarily plated with a flash of copper, then with a nickel deposit, and finally with chromium. Present shortage of nickel has forced manufacturers to use thinner plates of that metal than they would prefer to use, and has caused many of them, including the automobile manufacturers, to investigate other metal platings to replace or supplement the nickel. Bronze plating is now being studied by some of these users. Tests indicated that it possessed improved corrosion resistance to the plates obtained by present practice.

**PROPERTIES OF BRONZE PLATES**

| Approx Comp. of Deposit, % | Color | Hardness | Tarnish Resistance |
|---|---|---|---|
| 50–60 Copper<br>50–40 Tin | Bright silver-white | 400–420 Knoop | Better than silver or nickel |
| 80 Copper<br>20 Tin | Bright golden-yellow | 300–320 Knoop | Good; inferior to speculum plate, better than copper |
| 90 Copper<br>10 Tin | Golden red | 260–280 Knoop | Good, but interior to 80–20 bronze, better than copper |



**Power Shovel** with 45-cu-yd capacity has dipper stick, bail, bucket and teeth made from T-1 steel. Previous bucket, made of heavy castings, required more maintenance and its capacity was only 35 cu yd. *(All photos courtesy U.S. Steel Corp.)*

# New Tough
# High Strength Steel
## Cuts Fabrication Cost

*Constructional alloy has been used primarily in wear applications, but shows special promise for pressure vessels and highly-stressed structural parts.*

**by John B. Campbell,** *Associate Editor, Materials & Methods*

■ AFTER SEVERAL YEARS of successful trial application, a new and versatile constructional plate steel is now available in quantity. It is a quenched and tempered low-carbon alloy with exceptionally high yield strength, good toughness, unusually low transition temperature, good weldability, excellent abrasion resistance and relatively good atmospheric corrosion resistance.

The new steel, developed by United States Steel Corp., is known as USS T-1. A typical chemical composition is given in Table 1. However, T-1 steel plates are not supplied to composition limits but are furnished to meet minimum tensile properties. Minimum tensile strength of T-1 is 105,000 psi and minimum yield strength is 90,000 psi (see Table 4).

Present cost of T-1 steel is slightly more than 13 cents per pound. That is just about two and one-half times the cost of ordinary ASTM Grade B Firebox steels such as A201 or A212 which have minimum tensile strengths of 60,000 and 70,000 psi and minimum yield points of 32,000 and 38,000 psi, respectively.

Normally, T-1 plates are furnished in thicknesses from ¼ to 6 in., with some restrictions on sizes under ½ in. due to flatness requirements, and in standard widths up to and including 136 in. Maximum length is 450 in. Although T-1 is ordinarily furnished as quenched and tempered plate, it can also be obtained in the form of hot-rolled bars, semi-finished products or forgings.

### Applications

Compared with steels of lower yield strength, T-1 steel appears to offer significant economic advantages in three general types of applications:

1. Applications (such as pressure vessels) where T-1's higher cost-per-pound is more than offset by reduction in cross section. Savings result from both the lower cost of material and the secondary cost reductions attributable to less thickness, weight or bulk.

2. Applications (such as shovel buckets) where a smaller reduction in cross section may effect little or no saving in the cost of material, but where savings result from both the cost reductions attributable to less thickness, weight or bulk, and the cost reductions due to greater durability.

**TABLE 1—TYPICAL CHEMICAL COMPOSITION**

| Element | % |
|---|---|
| Carbon | 0.15 |
| Manganese | 0.75 |
| Phosphorus | 0.026 |
| Sulfur | 0.030 |
| Silicon | 0.24 |
| Nickel | 0.85 |
| Chromium | 0.50 |
| Molybdenum | 0.45 |
| Vanadium | 0.05 |
| Copper | 0.31 |
| Boron | 0.0029 |
| Iron | remainder |

3. Applications (such as mine car bottoms) where there is little or no reduction in cross section and the cost of the material is higher, but where savings still result from the cost reductions attributable to greater durability.

In all three cases, the fact that stress relieving is not usually required after welding T-1 steel often represents an additional cost reduction. Possible cost reductions attributable to less thickness, weight or bulk include reductions in the costs of welding, components, foundations, freight, erection and maintenance. Greater durability, resulting from high abrasion resistance, and good impact strength over a wide temperature range, is usually reflected in longer life, lower maintenance cost and less down time. A more specific list of applications is given in Table 2. The table also indicates how cost reductions are obtained in each case.

Up until now, T-1 has been used chiefly in mining, earth moving, materials handling and other industrial equipment where its abrasion resistance, impact strength or low-temperature toughness were most important. An outstanding example is the dipper stick of the power shovels on the Mesabi iron range which must withstand shock loading at temperatures as low as –50 F. Other examples include the tie plate for the columns of a steam hammer, lips for a bucket handling hot open hearth sinter, and blades for a rotating mixer used to distribute coke fines with blast furnace flue dust for sintering.

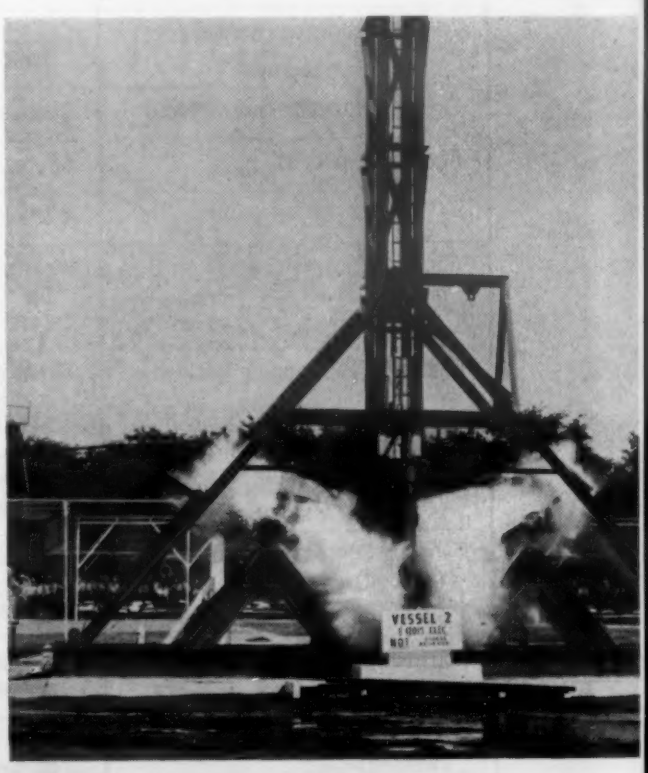
An outstanding example of the additional advantages often obtained as a result of reduction in weight or bulk is the bucket of a mammoth shovel used in strip mining; the capacity of the present bucket made from T-1 plate is 45 cu yd, compared to 35 cu yd for the previous bucket made of heavy castings.

Although T-1 has not yet been approved for use under the ASME or API-ASME Unfired Pressure Vessel Code, a number of pressure vessels have been made from T-1 plate. Aside from its higher strength, T-1 differs from steels normally used for pressure vessels in several important ways: it is a heat-treated steel, its yield strength is 85% of its tensile strength, and its ductility is somewhat lower than usual.

Economic design of T-1 welded pressure vessels is based on properties of the heat-treated metal, a practice not now permitted by the Code. The design stress is based on the yield strength instead of the tensile strength as currently required by the Code. However, both laboratory and field tests seem to indicate that the properties of heat-treated T-1 are not impaired by welding and that vessels designed to one-half of minimum yield strength operate with an ample margin of safety, even though the working stress is about 42% of minimum tensile strength instead of 25% as in Code vessels.

Tests also indicate that ductility is ample and suggest that "toughness" is more important. The toughness of T-1 is indicated by its good Charpy impact strength and its unusually low transition temperature, even in the as-welded condition. It is also believed that a 95% joint efficiency should not require a stress relieving operation, since tests indicate little or no improvement in tensile properties or transition temperature as a result of stress relief.

These concepts were put to test last summer when four cylindrical welded vessels made of ½-in. T-1 plate were subjected to burst and drop tests before an audience consisting of representatives of various regulatory groups concerned with pressure vessel construction. The vessels tested were 20 ft long, 4 ft in diameter and had welded hemi-




**Welded Pressure Vessels** made of T-1 took a lot of punishment before they succumbed to burst and drop loads in last summer's public tests. Results seemed to indicate significant cost savings could be obtained in such applications.

**Turbine Rotor Disks** must withstand high stresses at elevated temperatures. T-1 steel offers good high-temperature strength and creep-rupture properties.

spherical heads. Two of the vessels, refrigerated to –50 F, were subjected to increasing internal hydraulic pressure until they burst. The other two, refrigerated to –45 F, were subjected to repeated impacts by a 13-ton tup dropped from successive heights of 52, 73 and 101 ft. One vessel of each pair was tested as-welded, the other as stress relieved.

In the burst tests, both vessels withstood a pressure of 2850 psi, equivalent to a metal stress of 136,000 psi, before failing. In the impact tests, the vessels absorbed the 73-ft drop, equivalent to nearly 2,000,000 ft-lb of energy, without rupture and failed under the 101-ft drop (2,700,000 additional ft-lb). In all four tests, rupture occurred in a completely ductile manner. Welds were intact and no shattering occurred. The edges of the break indicated 100% shear along a 45-deg plane.

The extent and nature of the savings that can be achieved in pressure vessel construction by utilizing T-1 steel and the design concepts outlined above is indicated in Table 3.

An even more striking example is provided by field-erected spherical storage tanks. Assume that storage space is required for 25,000 bbl of propane to be contained at 210 psi. The Boiler Code, by limiting shell thickness to a maximum of 1¼ in. in vessels which are not stress relieved, limits the capacity of a carbon steel (ASTM A-201 Grade B) spherical vessel to about 1000 bbl at this pressure. Thus, it would take 25 vessels to provide the necessary storage. With T-1 steel, the required storage volume can be provided by a single vessel without exceeding the 1¼-in. thickness limit. The single T-1 vessel would save 66% in total shell weight, 14% in cost of shell metal, 70% in volume of weld metal and 84% in ground area covered.

Other T-1 applications where high yield strength, good weld-

**TABLE 2—HOW AND WHERE USS CARILLOY T-1 CAN REDUCE COSTS**

| Type Service and Fabrication | Typical Applications | Steel Costs | Welding Costs | Stress Relieving Costs | Components and Foundation Costs | Maintenance and Down Time Costs | Freight and Erection Costs |
|---|---|---|---|---|---|---|---|
| Tension (welded) | Pressure and storage vessels, line pipe, penstock, ladles and ladlehooks, eye bars, tension rods, flanges, fittings, crane parts | S | L | L | L | L | L |
| Tension (not welded) | Heavy machinery, rotating parts, flanges, fittings, gusset plates, bridge members, turbine disks | S | — | — | L | L | L |
| Tension, Abrasion (welded) | Coke bins, conveyor parts, hoppers; bucket lips, bails and doors; scraper blades | H | S | L | S | L | S |
| Tension, Abrasion (not welded) | Chain side links, bins, scraper blades, bucket parts | H | — | — | S | L | S |
| Abrasion (welded) | Chutes, storage bins, conveyor parts, brake disks, hoppers, ore car bottoms and doors, mill liners, truck-body liners | H | H | L | — | L | — |
| Abrasion (not welded) | Wear plates, bins, conveyor parts, hoppers, back-up plates, classifier shoes, mining equipment parts | H | — | — | — | L | — |
| Compression, Bending (welded) | Tower components, flex plates, lift forks, back-up plates, bases, housings, frames, power shovel handles | H | H | L | S | L | S |
| Compression, Bending (not welded) | Rotor end pieces, thrust plates, tie plates, dam plates, upsetter plates, frame structures | H | — | — | S | L | S |
| Tension, Compression, Bending (welded) | Wind tunnel flex plates, booms, housings, crane trolleys, dipper sticks, open hearth doors, gun carriage, catapult parts, frame structures | H | S | L | S | L | S |
| Tension, Compression, Bending (not welded) | Stiffeners, testing equipment parts, heavy machinery and machine tool parts | H | — | — | S | L | S |
| Abrasion, Compression, Bending (welded) | Cutter bars, liners, housings, frames, bases, bucket teeth | H | H | L | S | L | S |
| Abrasion, Compression, Bending (not welded) | Linings, chutes, bins, screens | H | — | — | S | L | S |
| Combined Stresses, but Primarily Impact and Abrasion (welded) | Bucket lips, mine car bottoms, truck bodies and bottoms, impact plates, car wheels, drag buckets, liner plates, skip hoists, gun carriages | H | H | L | S | L | — |

*LEGEND: Cost of using T-1 instead of a lower yield strength steel will be:*

*L = much less, depending on design.*
*S = about same or slightly less, depending on design.*
*H = higher, since reduction of cross section not practical.*

ability and general ease of fabrication are of primary importance include high-stress bridge members, turbine disks and a rotor for a large synchronous condenser.

### Properties

T-1 is furnished to meet minimum tensile properties. As Table 4 indicates, these are: 105,000 psi tensile strength, 90,000 psi yield strength, 16 to 18% elongation in 2 in., and 45 to 55% reduction of area. Although ductility decreases somewhat with thickness, the strength of T-1, unlike that of most plate steels, is independent of thickness within the range produced.

Impact strength of heat-treated T-1, as measured by the longitudinal keyhold Charpy test, ordinarily ranges from 25 to 35 ft-lb at atmospheric temperatures. The longitudinal ductility transition temperatures at which Charpy impact strength of heat-treated T-1 drops to 15 ft lb appears to range from –255 F to a maximum of –150 F. The ductility transition temperature of as-welded T-1, as measured by the Kinzel test, falls in the range from –70 to –90 F (see Table 5).

Hardness of heat-treated T-1 is ordinarily about 250 BHN, but it can be furnished to a minimum Brinell hardness of 321 for applications requiring only maximum resistance to abrasion.

Maximum suitable service temperature for T-1 is about 900 F. At that temperature, the creep-rupture strength of T-1 is about three times that of carbon steel, about one and one-third that of ½% molybdenum steel, and about equal to that of ½-molybdenum, ½%-chromium steel. Creep and stress-rupture data for T-1 at 900, 1000 and 1100 are shown in Fig 1 and 2. The stress needed to cause rupture in 1000 hr is 59,000 psi at 900 F, 23,000 at 1000 F and 10,000 at 1100 F. The 10,000-hr rupture stress is 44,000 at 900 F, 14,000 at 1000 F and 6000 at 1100 F. Similarly, the stress needed to cause 1% creep in 10,000 hr is 44,000 psi at 900 F, 10,000 at 1000 F and 2300 at 1100 F.

Short-time strength of T-1 at elevated temperatures is shown in Fig 3. Endurance limit (pulsating fatigue) of unwelded T-1 is about 50,000 psi. Thermal coefficient of linear expansion is $7.73 \times 10^{-6}$ in./in./°F in the 32-1300 F range, about the same as that of 0.70% carbon steel. On the basis of 18-month exposure tests, resistance to atmospheric corrosion is conservatively estimated to be four times that of carbon steel. Electrical and magnetic properties are still being determined.

### Fabrication

The high strength of T-1 is obtainable only by heat treatment, and the steel is ordinarily supplied in the heat treated condition. If hot working (above 1200 F) is necessary or desirable, however, the steel can be obtained in the hot rolled condition and subsequently heat treated by quenching from 1650 F and tempering at 1150-1200 F. Quenching following tempering is con-

**TABLE 4—MINIMUM PROPERTIES OF HEAT TREATED PLATE**

| Property \ Thickness | ¼ to 2 in. incl. | Over 2 to 4 in. incl. | Over 4 to 6 in. incl. |
|---|---|---|---|
| Yield Strength (ext. under load), psi | 90,000 | 90,000 | 90,000 |
| Tensile Strength, psi | 105,000 | 105,000 | 105,000 |
| Elongation, % | 18 | 17 | 16 |
| Reduction of Area, % | 55 | 50 | 45 |

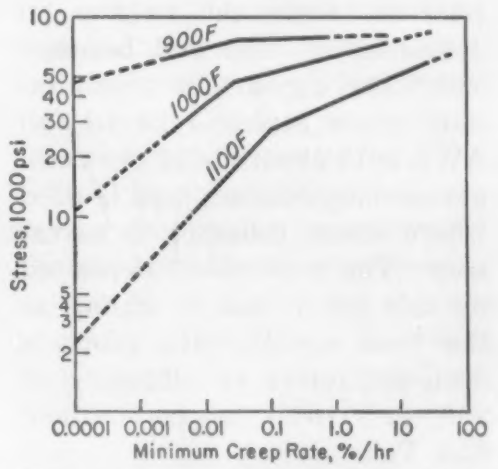



Fig 1—Creep curves for T-1 steel.

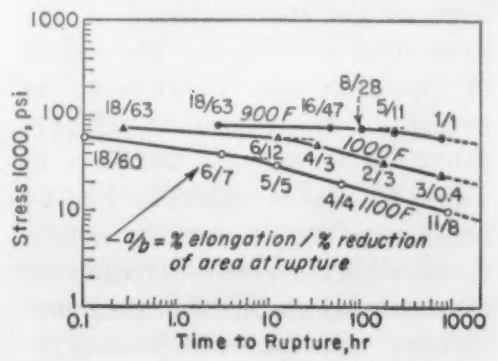



Fig 2 — Stress-rupture curves for T-1.

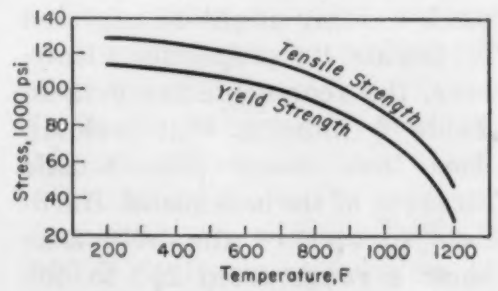



Fig 3—Short-time strength of T-1 at elevated temperatures.

**TABLE 3—SAVINGS POSSIBLE IN 1000-BBL CYLINDRICAL PRESSURE VESSEL TO OPERATE AT 525 PSI**

| | A 212 Grade B | USS Carilloy T-1 |
|---|---|---|
| Yield Strength (min), psi | 38,000 (Y.P.) | 90,000 |
| Tensile Strength (min), psi | 70,000 | 105,000 |
| Design Stress, psi | 70,000 x 0.25 = 17,500 | 90,000 x 0.5 = 45,000 |
| Thickness of Shell (stress relieved and x-rayed, joint efficiency 95%), in. | 2.18 | 0.84 |
| Weight of Shell Material, lb | 193,000 | 73,480 |
| Cost of Shell Material, $: | | |
| Atm. Temp. Svc. | 10,130 | 9660 |
| –50 F Svc. | 14,000 | 10,770 |
| Weight of One 20-in. Manhole, lb | 966 | 522 |
| Volume of Weld Metal, cu in. | 5300 | 1200 |
| Volume of Concrete Required in Foundation, cu yd | 20 | 18 |

sidered desirable.

Heat treated T-1 can be readily flame-cut and no special precautions are needed to avoid cracking. Because of the alloy content, however, the cut edge will be hard (up to 400 BHN) though tough, and preheating at 350 F may be desirable to aid subsequent edge machining. As-rolled, T-1 does not have the same degree of toughness and should be preheated at 400 F to avoid cracking during flame cutting.

T-1 can be welded without preheating with no danger of underbead cracking if a low-hydrogen-coated electrode is used. Cellulose-coated electrodes are not suitable. An AWS 12015 electrode should be used where 100% joint efficiency is necessary and the weldment is not to be stress relieved. Since the weld metal deposited by this rod becomes embrittled by carbide precipitation when stress relieved, an AWS 9015 electrode of the manganese-molybdenum type is used where stress relieving is necessary. The weld metal deposited by this rod is not as strong as the base metal; with properly designed joints an efficiency of 90% or greater can be obtained (see Table 6).

Stress relieving of T-1 weldments is not usually necessary because the steel is tough in the as-welded condition. The effect of welding on toughness, as measured by transition temperature, is shown by the data in Table 5. Stress relieving may be necessary under certain conditions where stress corrosion or dimensional stability during machining are factors. Stress relieving temperatures should not exceed 1150 F.

Since T-1 is a heat-treated steel, welding might be expected to impair its properties. However, the representative data in Table 6 indicate that welding does not lower the tensile strength of the base metal. Hardness surveys of the weld zone show a range from 260 to 400 VPN for a plate with an original hardness of about 300 VPN.

**TABLE 5—TRANSITION TEMPERATURES FOR WELDED SPECIMENS**

| Material | Condition | Electrode | Type Test | Transition Temp, F | |
|---|---|---|---|---|---|
| | | | | Ductility | Fracture |
| ½-in. Plate | Unwelded | — | Kinzel | −132 | −102 |
| | As Welded | E 12015 | Kinzel | −78 | −84 |
| | | E 6010 | | −84 | −92 |
| | | E 12015 | Tee Bend | −180 | −62 |
| | | E 6010 | | −128 | −100 |
| 1-in. Plate | Unwelded | — | Kinzel | Below −143 | −76 |
| | As Welded | E 12015 | Kinzel | −72 | −44 |
| | | E 6010 | | −78 | −64 |
| | | E 12015 | Tee Bend | −144 | −40 |
| | | E 6010 | | −124 | −72 |

**TABLE 6—EFFECT OF WELDING ON TENSILE STRENGTH OF 1-IN. PLATE**

| Electrode | Condition | Tensile Strength, psi | Location of Failure | Joint Efficiency, % |
|---|---|---|---|---|
| — | As Heat-treated | 123,400 | Base Metal | 100 |
| E 12015 | As Welded | 123,500 | Base Metal | 100 |
| E 9015 | As Welded | 117,000 | Weld Metal | 93.8 |
| | Stress Relieved | 113,900 | Weld Metal | 91.4 |

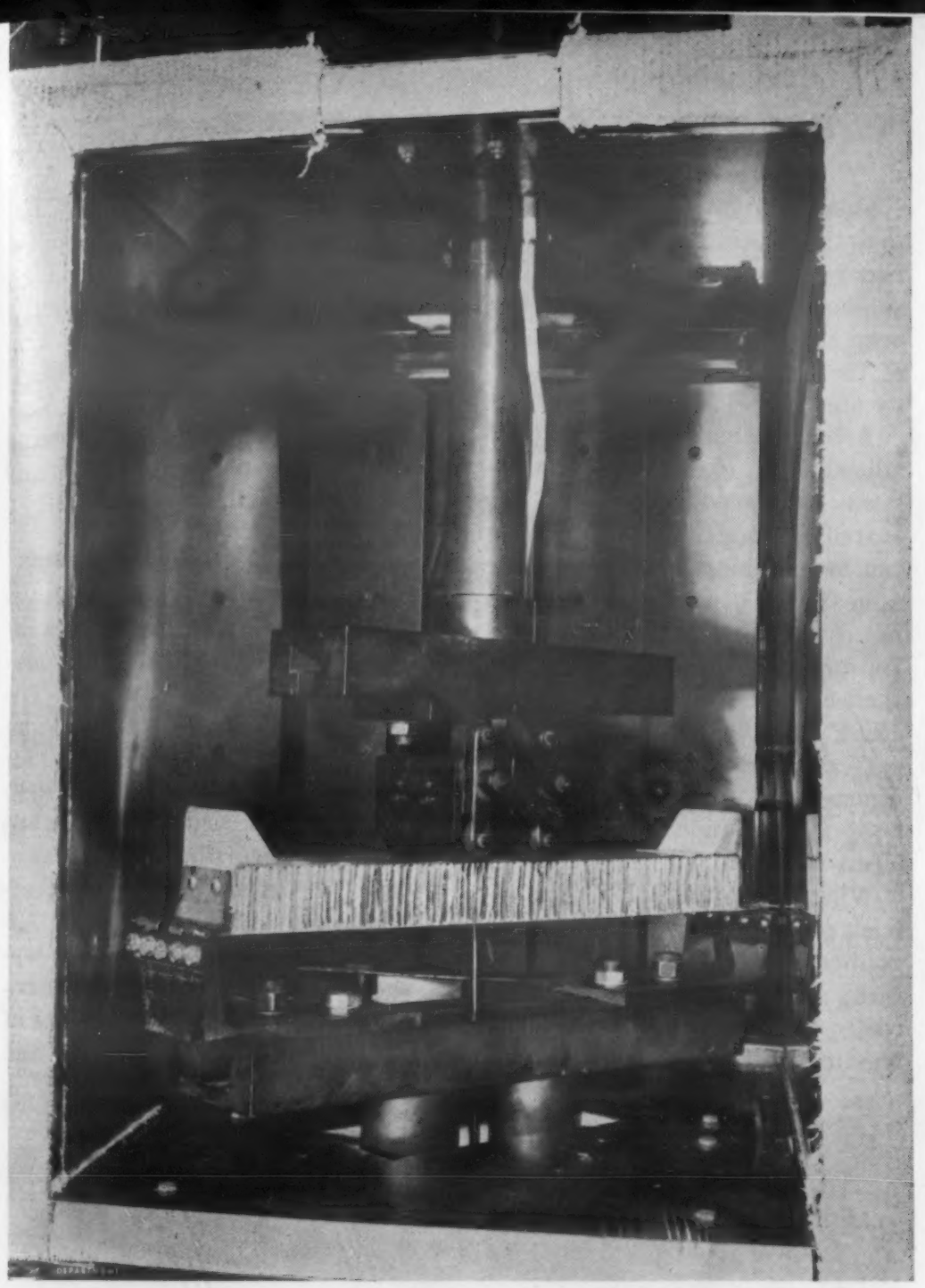
No particular difficulties have been encountered in cold forming and bending, although, because of its high yield strength, T-1 requires considerably more bending force than comparable sections of other constructional steels. Use of the largest possible bending radius is desirable. For bending about an axis transverse to the final rolling direction, the suggested minimum radius is 2T for plates up to 1 in. thick and 3T for heavier plates up to 2 in. Bending with the axis of bend parallel to the final rolling direction should be avoided where possible. Heavier plates require considerably more power but can be cold bent if sufficiently generous radii are used. The effects of cold forming and cold forming followed by aging on transition temperature appear to be less for T-1 than for most steels, and there appears to be no need for stress relieving (see Table 7).

**TABLE 7—EFFECT OF STRAINING AND STRAIN AGING ON TRANSITION TEMPERATURE**

| Condition | Transition Temp, F[1] |
|---|---|
| Unstrained | −175 |
| Strained 10% by Cold Rolling | −155 |
| Strained 10% by Cold Rolling and Aged 1 hr at 550 F | −135 |
| Strained 10% by Cold Rolling and Stress Relieved 1 hr at 1100 F | −180 |

[1] *Longitudinal Charpy keyhole test.*

Machining practices recommended for T-1 are those used for steels of similar hardness (235-285 BHN). Compared to carbon steel, lower rates and shorter tool life must be expected because of the higher strength.



The flexural test is probably the most reliable test for evaluating an adhesive in conformance with practical requirements since the tendency for compression buckling in the faces can be duplicated.

# New Heat Resistant Adhesives

## For Metal Bonding

*Developed for the fabrication of missile structures, these adhesives can serve also in automotive, aircraft and electronic parts.*

by **George Epstein,**

*Research Engineer, Aerophysics Dept., North American Aviation, Inc.*

■ TWO HEAT RESISTANT adhesives suitable for structural applications at temperatures as high as 600 F have been developed by North American. The first, NAA Hi-Temp, is especially suitable for metal-to-metal adhesive bonding. The second, CHT, is a modification designed for the fabrication of heat resistant sandwich constructions. These adhesives are being used in the fabrication of missile structures.

Essential requirements in the development of heat resistant adhesives for structural applications are: the adhesive must resist elevated temperatures, and fabrication must be feasible.

Because of their inherent heat-resistant properties, phenolic resins with alkaline catalysts were selected as the basic materials for use in the development of these adhesives. After developing a suitable composition, investigation showed that a two-stage cure gave optimum results.

The procedure involves air-drying to evaporate practically all solvents followed by precuring at 180 F. At this stage, the adhesive film should be soft enough to be marked by a finger-nail but no longer tacky. This stage has been designated "soft set." The final stage involves curing at 275 F under pressure.

The novelty of this procedure is the inclusion of the precure to obtain increased strength at elevated temperatures. Tests on several commercial phenolic adhesives showed that the addition of this step resulted in as much as a three-fold increase in the tensile-shear strength of aluminum specimens tested at 500 F.

### Bonding Methods

The most suitable surface preparations are those generally recommended by U. S. Forest Products Laboratory, Madison, Wisconsin. For aluminum alloys, degreasing followed by a 10 min immersion in a warm (150 to 170 F) sulfuric acid-sodium dichromate solution has been found ideal. Attempts to employ

proprietary etching solutions have often resulted in wide variations in bond strength. Stainless steels are generally prepared by dipping for a few minutes in a dilute hydrofluoric-nitric acid bath. Light sandblasting and simple solvent degreasing have been found satisfactory, also. Best results with titanium alloys have been obtained by carefully anodizing the surface of the material before bonding. Fair results have been obtained by an acid dip treatment.

Only heat resistant plastic materials require adhesives suitable for elevated-temperature operation. When NAA Hi-Temp or CHT adhesives are employed with glass-reinforced plastics, the plastics surface need only be sanded and degreased prior to application of the adhesive. For low pressure laminates a seal coat of adhesive has generally been found advisable in order to seal the porous surface. This consists of a thin coat of the adhesive which is air dried and baked before employing the customary bonding steps.

NAA Hi-Temp can be applied to surfaces by any of three methods: 1) brush, 2) trowel (or spatula), 3) spray. When spraying, the liquid adhesive is thinned with acetone to 10 to 25% solids content. CHT adhesive has been successfully applied by both of the first two methods but not by spraying.

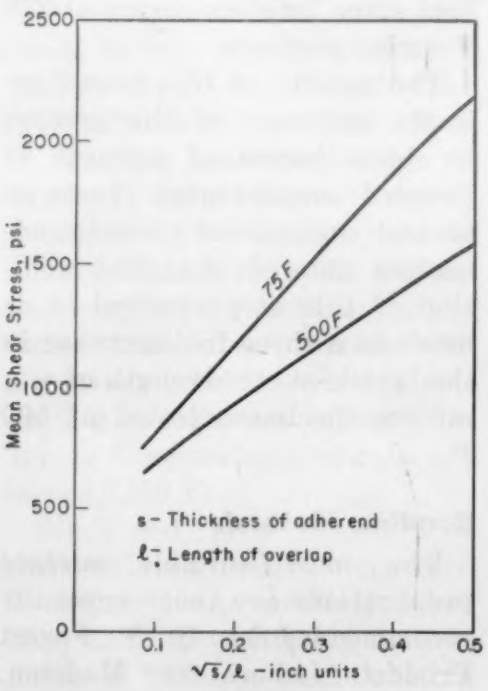
After application of the liquid adhesive, a glass fabric interlayer is placed on one of the coated surfaces. This interlayer can be pre-impregnated with the adhesive, if desirable, but this is not essential. Parts are air dried for one hour, or longer. They are then oven dried for one hour at 180 F in order to reach the "soft set" stage described previously, assembled and cured at 275 F for 60 to 90 min under a pressure of 50 to 100 psi.

When employing CHT in sandwich construction the adhesive is applied only to the facing surfaces and need not be applied directly to the core materials. For plastic sandwich components, a prime coat of sprayable NAA Hi-Temp solution is first applied. Such a prime coat, applied by dipping to core materials, results in improved filleting and is employed for both metal and plastic honeycomb constructions. Vacuum-bag techniques employing 15-psi pressure have been found good for skin-to-core bonding.

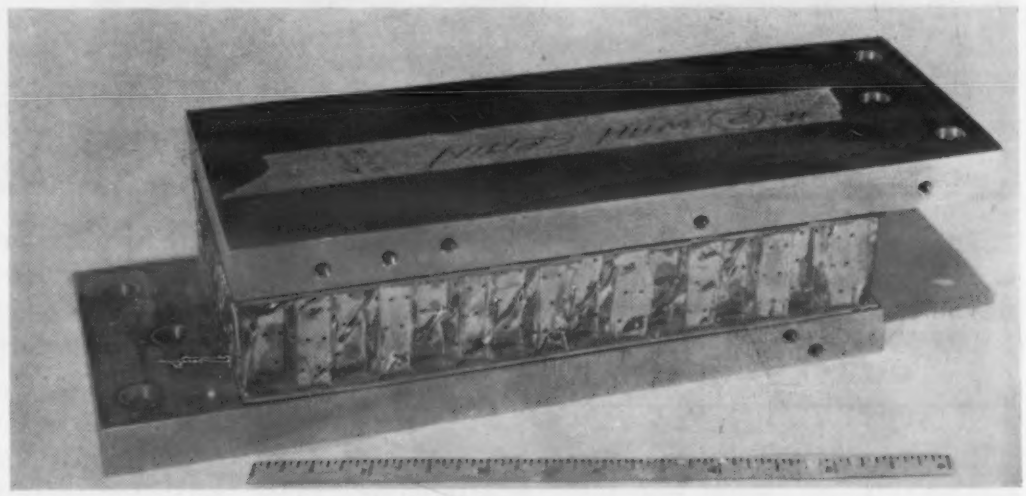
### Properties of Adhesive Bonds

An accompanying table gives the tensile-shear properties of NAA Hi-Temp adhesive bonds on a number of materials. The shear strength of 2024-T3 aluminum remains above 1000 psi for temperatures up to 600 F indicating that structures can be designed accordingly.

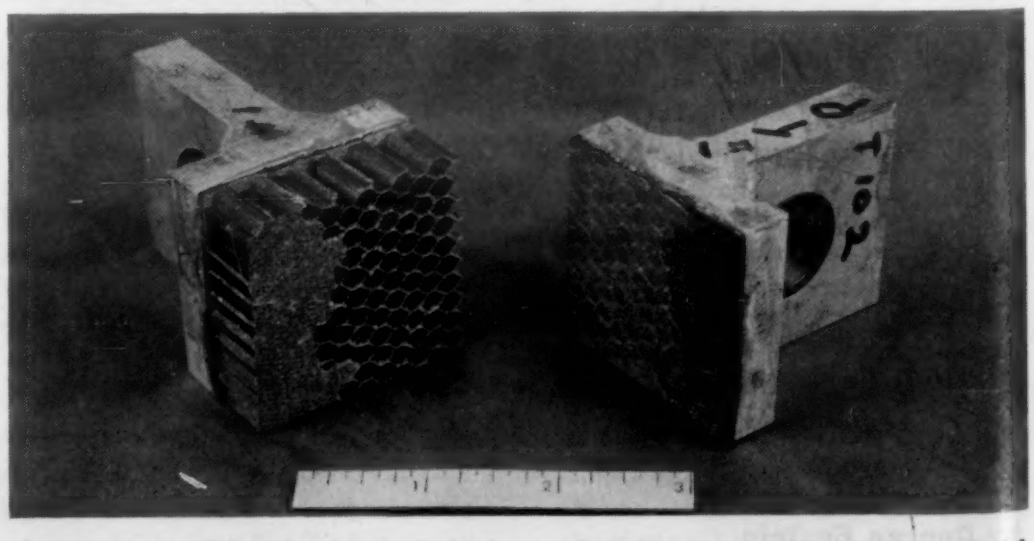
On the other hand, bend tests conducted according to U.S. Air Force Spec MIL-A-5090B on lap-shear specimens of this aluminum alloy gave bend strengths of 112 lb at room temperature and




Variation of strength with joint factor for NAA Hi-Temp bonds. From these curves the expected shear strength of a lap joint can be determined if the adherend thickness and overlap length are known.



Block-shear tests at 500 F on specimens of this type generally result in shear failure within the aluminum honeycomb core.



Appearance of break obtained during a flatwise tensile test of a sandwich structure.

at 500 F. The room temperature results are appreciably lower than the 150 lb required by the specification, but are similar to those obtained on most high-temperature adhesives. It is expected that the Air Force will take this deviation into account in preparing specifications for heat-resistant adhesives.

**ALUMINUM SANDWICH FLEXURAL TESTS**
(EFFECT OF INTERLAYER)

| Adhesive Interlayer | Max Core Shear Stress (psi) | Max Facing Stress (psi) |
|---|---|---|
| Scrim | 189 | 27,070 |
| 181 | 205 | 29,100 |
| 112 | 205 | 29,570 |

*NOTE: All tests at 500 F after ½-hr exposure to 500 F.*

**EFFECT OF VARIATIONS IN APPLICATION OF PRESSURE DURING CURE (NAA HI-TEMP)**

| Pressure Source | Tensile-Shear Str, psi | |
|---|---|---|
| | 75 F | 500 F* |
| C-Clamps | 1300 | 1300 |
| Vacuum | 1710 | 1530 |
| Platen Press | 2000 | 1600 |

** Tested after ½-hr exposure to 500 F.*

Values shown in the table for Titanium alloy RC-130 were obtained on metal which had received a special anodizing surface treatment. Appreciably lower results, 350 psi at room temperature and 250 psi at 500 F, were obtained when the surface was prepared by treatment with Iridite No. 14. This illustrates the importance of surface treatment and particularly the desirability of a controlled oxide surface film on titanium alloys which are to be bonded with NAA Hi-Temp.

Stainless steel surfaces were generally prepared by sandblasting before bonding. However, comparable results were obtained by etching the surface with dilute nitric-hydrofluoric acid solution or by simply degreasing the surface with a suitable solvent. Surface preparation of stainless steels, therefore, does not appear to be a particular problem.

Glass reinforced plastics laminates gave ultimate stresses of 1000 psi but there was evidence of failure between plies of the laminate at lower stresses.

The strength of the bonds was investigated also by a number of creep-rupture tests. These were run at both room temperature and 500 F using tensile loads of 1000-1100 psi. Tests were conducted for 9 hr. No failures had occurred and the total deformation in the bonded area after testing at 500 F was less than 0.003 in.

The peel strength of NAA Hi-Temp adhesive bonds were compared with those of several commercially available structural adhesives. One-inch wide strips of 2024-T3 aluminum sheet, 0.016 in. thick, were adhesive bonded to 0.250-in. thick strips and tested on a drum-type peel apparatus. The peel strength was observed to be approximately the same as that of Epon VIII adhesive (Shell Chemical Corp. and approximately one-fifth that of Redux K-6 (Ciba Co., Inc.) and Metlbond MN3C tape (Narmco Resins & Coatings, Inc.) adhesives when similarly tested. Hence parts bonded with NAA Hi-Temp adhesive would be subject to the same handling precautions and edge design considerations as those employed when bonding with other brittle adhesives. It is of interest to note that after exposure to 500 F for five hours, peel strengths were observed to increase about threefold.

The fatigue strength of both NAA Hi-Temp and CHT adhesives (metal-to-metal) is in excess of the requirements of specification MIL-A-8331 (recently superseded by MIL-A-5090B), i.e. greater than $10^6$ cycles of axial loadings at 650 psi.

**TENSILE-SHEAR PROPERTIES OF NAA HI-TEMP ADHESIVE BONDS**

| Adherend Material | Test Temp, F* | Shear Str, psi |
|---|---|---|
| Aluminum, 2024-T3 clad 0.064 in. thick | 75 | 2000 |
| | 500 | 1600** |
| | 600 | 1200 |
| | 700 | 650 |
| Titanium, RC-130A, 0.05 in. thick | 75 | 1900 |
| | 500 | 1000 |
| Stainless Steel, 17-7, 0.020 in. thick | 75 | 1625 |
| | 500 | 1615 |
| | 700 | 775 |
| Stainless Steel, 18-8, 0.020 in. thick | 75 | 2400 |
| | 500 | 2140 |
| | 700 | 725 |
| Glass-Reinforced Plastic Laminate (CTL-91-LD, 181-114 fabric) | 75 | Specimens usually fail in interlaminar shear (approx 1000 psi) |

** All specimens were exposed to elevated temperatures for ½ hr before testing at that temperature.*
*** Values as high as 1800 psi have been obtained for aluminum lap-shear specimens tested at 500 F*
*NOTE: All specimens were tested in accordance with U. S. Air Force Spec. MIL-A-8331.*

### Applying Pressure During Cure

In general, test specimens are fabricated by curing of the adhesive bonds in a platen press. Applications are often encountered, however, where it would be desirable to cure the adhesive bond under pressures provided either by clamping (as with C-clamps) or through use of vacuum-bag bonding techniques. Accordingly, tests were conducted with NAA Hi-Temp using these sources of pressure and an oven as the heating medium. By using suitable tooling, a pressure of 90 psi on the adhesive bonded area was obtained with vacuum-

bag bonding technique. No estimate of the pressure was made when using the C-clamps other than the fact that the C-clamps were tight. Results obtained for aluminum lap-shear specimens are shown in a table and indicate that target strength requirements 1000 psi at 500 F are met using both alternate methods of applying pressure. The lower values obtained with C-clamps result probably from lower pressure during cure.

**Exposure Effects**

During fabrication and use, adhesive-bonded parts are subjected to various environments. Accordingly, adhesive-b o n d e d specimens were exposed to some of those conditions felt most important in missile design.

Aluminum lap-shear test specimens prepared with NAA Hi-Temp adhesive, were immersed for one hour in boiling tap water. Specimens were then tested in tensile shear both at room temperature and at 500 F (½-hr exposure to 500 F before testing). There was no loss in strength at either temperature.

Lap-shear specimens prepared from 2024-T3 clad aluminum with NAA Hi-Temp were exposed to the sulfuric acid-sodium dichromate cleaning treatment generally employed for aluminum alloys. They were immersed for 10 min in a solution maintained at a temperature of 160 ±10 F and consisting of 30 parts water, 10 parts concentrated sulfuric acid, and 1 part sodium dichromate. Specimens were then washed under tap water and dried. These were tested at room temperature and at 500 F (after ½-hr exposure to 500 F). No impairment in tensile-shear strength was observed as a result of the exposure to the acid-cleaning treatment.

Aluminum lap-shear specimens prepared with CHT and NAA Hi-Temp adhesives were exposed for various periods of time to temperatures of approximately 500 F by placing in a pre-heated oven. After a five-hour exposure to 510 ±10 F, CHT-bonded specimens retained over 80% of the original tensile-shear strength both at room temperature and at 500 F (after ½-hr exposure to 500 F).

NAA Hi-Temp adhesive-bonded lap-shear specimens were exposed to two temperature cycles, each consisting of five hours at 500 F. Specimens tested at room temperature retained 70% of the original strength. Those tested at 500 F after an additional ½-hr exposure to 500 F, retained over 90% of their 500 F tensile-shear strength.

**CHT in Sandwich Construction**

CHT adhesive has been successfully employed in the skin-to-core bonding of all-metal (aluminum) and all-plastic (glass-reinforced) sandwich constructions and in the splicing of honeycomb cores. In conjunction with Shell Development Company's 422 adhesive or Narmco 302, it has been found advisable to employ CHT as a seal coat for low pressure glass-reinforced plastic laminates.

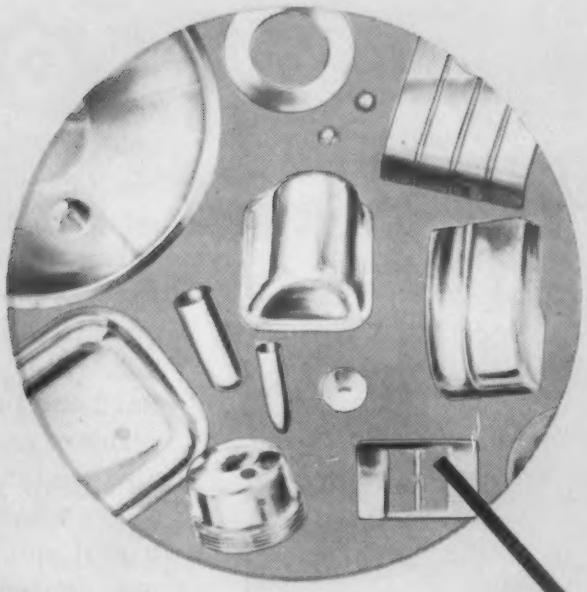
Flexural beam specimens, 3 in. by 16 in., were prepared using CHT adhesive in the skin-to-core bond between 0.032 in. 2024-T3 aluminum facings and aluminum hexagonal honeycomb cores (⅝ in. thick, ¼-in. cell size, and 0.003-in. wall thickness). Various types of glass fabric interlayers were investigated including a scrim fabric, a type 181 fabric, and a type 112 fabric. Three specimens of each type were tested at 500 F (after ½-hr exposure) in two-point loading with a 14-in. support span and a 4.81-in. loading span. In all cases failure resulted due to shear in the core, and not in the adhesive bond. However, greatest stabilization of skin and core and minimum glue-line weight occurred with the 112 fabric (Volan A finish) interlayer.

The cores failed at a shear stress of about 200 psi at 500 F, a value some thirty percent greater than that to be anticipated from published literature. Thus, the CHT adhesive had stabilized the core to a large extent, and provided a bond between the aluminum skin and this core strong enough to resist forces sufficient to cause failure of the core in shear. Similar results have been obtained using: 1) other aluminum hexagonal honeycomb cores (e.g., ½ by 0.0015-in. core), 2) thinner facings (0.016 in. 2024-T3 aluminum), and 3) other loading spans (e.g., 2.50, 6.62, 6.90, and 9.00 in.)

When tested in flatwise tension at 500 F (after ½-hr exposure to 500 F), 3 by 3-in. aluminum sandwich specimens (¼ by 0.003-in. hexagonal core) have developed ultimate stresses in excess of 350 psi by successfully resisting loads greater than 3200 lb at 500 F. Block-shear tests at 500 F generally result in shear failure within the aluminum honeycomb core.

Similar flatwise-tensile and block-shear test results were obtained for glass-reinforced plastic sandwich structures. Flexural two-point loaded beam tests at 500 F after a ½-hr exposure period at 500 F, result in compressive failure in the plastic laminate (181 glass fabric) facings at stresses of approximately 30,000 psi or in shear failure in the core (usually 20 to 30% higher than published allowables) depending on which sandwich component has been made critical by choice of loading arm distance. The adhesive allows stressing of the sandwich components to or above their published allowables without premature failure of the bond. Compressive failures at stress levels in excess of 33,000 psi have been obtained for facings when sandwiches were tested after 5-hr exposure to 500 F.

At the present time these adhesives are being employed in the fabrication of structural components for guided missiles, as for example in a prototype guidance compartment door of metal sandwich construction as well as in numerous non-structural applications where heat-resistance is required.



## Formed Shapes

## Cold Headed Parts

## Forgings

# Wrought Non-Leaded Brasses

**by John L. Everhart,** *Associate Editor, Materials & Methods*

**MATERIALS & METHODS MANUAL No. 112**

**This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.**

**JANUARY 1955**

The wrought non-leaded brasses are probably the most widely used of the copper alloys. Their properties vary with composition but as a group they are quite strong, have excellent ductility, have good corrosion resistance and are colorful.

To assist in the selection of the proper grade for a suitable application, this Manual presents information on the following points:

- Commercial Grades
- Engineering Properties
- Forming and Fabricating
- Joining Practice
- Cleaning and Finishing
- Applications

*Cover Photos: American Brass Co. and Chase Brass & Copper Co., Inc.*

ALPHA BRASSES are cold-rolled to strip for production of stampings and deep drawn parts. (Copper & Brass Research Assoc.)

■ BRASSES ARE PROBABLY the most useful of all copper alloys and account for a large share of the copper alloy production. Although there are numerous modified brasses, particularly those containing lead, brass is basically an alloy of copper and zinc. These two-component alloys which are widely used in the wrought form, are called common brasses, plain brasses and so forth. A more descriptive term, *non-leaded brass* is generally employed by the brass industry and is used by the Copper & Brass Research Association in the Manual of Standards.

The commercial non-leaded brasses range from 95% copper-5% zinc to 60% copper-40% zinc. Their properties vary with composition but as a group they are quite strong, have excellent ductility, have good corrosion resistance and are quite colorful.

As will be discussed later, these brasses divide into two groups—single phase alloys and two phase alloys—on the basis of internal structure. However, there is another breakdown which is used frequently. Brasses containing 20% or less zinc are called *low brasses*, those containing more than 20% zinc are called *high brasses*. This breakdown results from certain property characteristics. For example, in resistance to corrosive attack, the low brasses form one group while the high brasses form another with different degrees of resistance. This is indicated in a table.

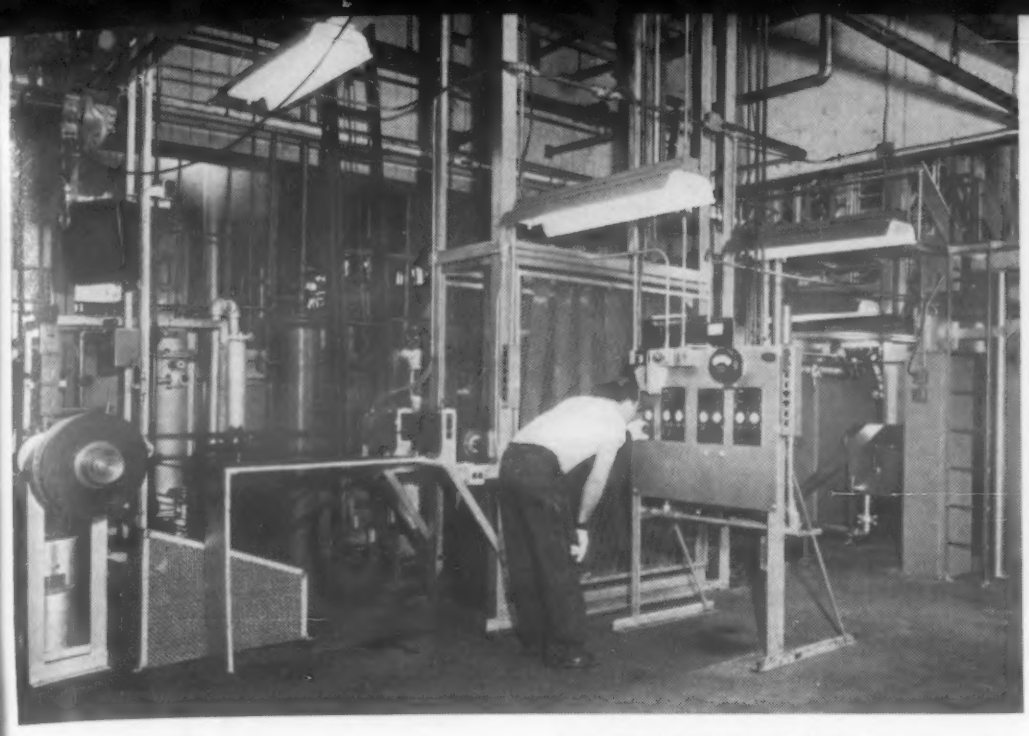
This Manual discusses the properties of the most commonly used wrought non-leaded brasses, their fabricating characteristics and some of their applications. Emphasis is placed on the manner in which they differ among themselves and from other materials to assist the engineer in selecting the proper alloy for his application.

### Classification of brasses

Zinc is soluble in liquid copper but the solubility in the solid state is limited. Brasses containing less than 37% zinc are solid solutions, and have a structure similar to that of pure copper. Increasing the zinc content beyond this composition results in the formation of a second constituent and the alloys have a two phase structure. This second phase is hard and brittle and the practical result of continued increase in the zinc content is the production of alloys which are unworkable. The useful duplex alloys, therefore, are limited to a rather narrow range from about 37 to 45% zinc. Alloys containing more than 45% zinc are used only as brazing materials.

The commercial non-leaded brasses divide logically into two groups based on their structural characteristics. Brasses containing less than 37% zinc, the alpha brasses, combine good strength with excellent ductility. As a result they are used widely in the production of parts which are fabricated by cold-working. Brasses, containing from 37 to 45% zinc, consist of alpha and beta brass. The hard beta crystals increase the strength of brass but lower its ductility. However, when these duplex brasses are heated, the beta constituent makes the brass plastic over a wide temperature range and these alloys have excellent hot working characteristics.

Brasses have been in use for centuries. Over the years many varieties have been produced. Frequently the alloys differed only slightly in composition and their properties were quite similar, but names such as high brass, buckle brass or drawing brass failed to indicate the similarity. Considerable confusion resulted particularly in attempting to duplicate a grade which had been



ANNEALING BRASS to superfine grain in a high-speed continuous Selas furnace at the plant of the Somers Brass Co.

found to work satisfactorily in some specific application.

To clarify the situation, the Copper & Brass Research Association has publicized a group of seven alloys covering the range of properties generally required in the non-leaded brasses. This list is given in an accompanying table. Another table indicates some of the alternate names which have been used for these alloys. The seven alloys account for most of the wrought non-leaded brass produced yearly and are representative of such brasses. Therefore, this Manual is limited to a discussion of their properties. There are other alloys widely used for specialties. One of these is jewelry brass which contains 87% copper, a composition mid-way between that of commercial bronze, 90% and red brass, 85%. A reasonable approximation of its properties can be obtained from those of the two standard alloys. Similarly, a yellow brass containing 63% copper, used specifically as wire, has properties resembling those of the standard yellow brass.

Six of the seven alloys which the brass mill industry considers standard are alpha-brasses, ranging in composition from 95% to 65% copper. The seventh alloy, Muntz metal, is a duplex brass containing 60% copper. Various commercial forms of these materials are covered by ASTM specifications. A listing is given in a table to assist the engineer in locating applicable industry-wide standards.

**TABLE 1—NOMINAL COMPOSITIONS OF NON-LEADED BRASSES**

| Designation | Composition, % | |
|---|---|---|
| | Copper | Zinc |
| Gilding, 95% | 95 | 5 |
| Commercial Bronze, 90% | 90 | 10 |
| Red Brass, 85% | 85 | 15 |
| Low Brass, 80% | 80 | 20 |
| Cartridge Brass, 70% | 70 | 30 |
| Yellow Brass | 65 | 35 |
| Muntz Metal | 60 | 40 |

**TABLE 2—NOMENCLATURE**

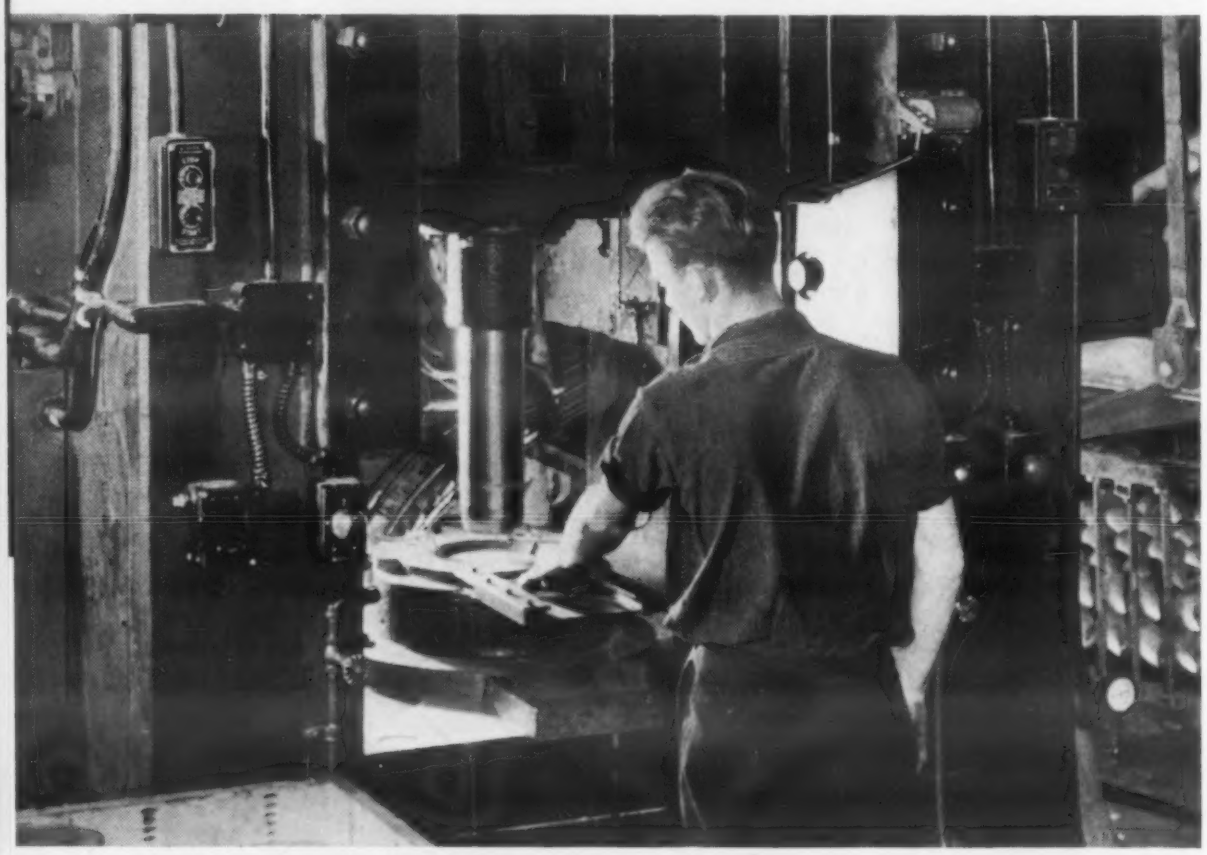
| Preferred Name | Some names formerly used (not recommended) |
|---|---|
| Gilding, 95% | Commercial Bronze 95%, Gilding Metal, Cartridge Gilding, Percussion Cap |
| Commercial Bronze, 90% | Gilding Metal, Commercial Bronze, Talmi Gold, Best Bronze, Rich Gold Metal, Cap Gilding |
| Red Brass, 85% | Rich Low Brass, Red Brass, Brazing Metal |
| Low Brass, 80% | Low Brass, 80–20 Brass, Red Brass 80%, Rolled Brass, Common Low Brass |
| Cartridge Brass, 70% | Cartridge Brass, Spinning Brass, Spring Brass, Extra Quality Brass, 70–30 Brass, Deep Drawing Brass, Grommet Brass |
| Yellow Brass | Drawing Brass, High Brass, Hoop Brass, Common High Brass, Buckle Brass, Door Plate Brass |
| Muntz Metal | Yellow Metal, Washer Brass, Check Brass, Burr Brass |

**TABLE 3—NEAREST APPLICABLE ASTM SPECIFICATIONS**

| Designation | Rolled Flat Products | Drawn Flat Products[c] | Wire | Tube |
|---|---|---|---|---|
| Gilding, 95% | B36, No. 1<br>B134, No. 1 | B134, No. 1 | B134, No. 1 | — |
| Commercial Bronze, 90% | B36, No. 2, B130,<br>B134, No. 2 | B134, No. 2 | B134, No. 2 | — |
| Red Brass, 85%[a] | B36, No. 3<br>B134, No. 3 | B134, No. 3 | B134, No. 3 | B135, No. 1<br>B111 |
| Low Brass, 80% | B36, No. 4<br>B134, No. 4 | B134, No. 4 | B134, No. 4 | — |
| Cartridge Brass, 70% | B19, B36, No. 6<br>B134, No. 6 | B134, No. 6 | B134, No. 6 | B135, No. 2<br>B14 |
| Yellow Brass | B36, No. 8<br>B134, No. 7 | B134, No. 7 | B134, No. 7[b] | — |
| Muntz Metal | — | — | B134, No. 8 | B111<br>B135, No. 5 |

[a] *B-43 for pipe.*
[b] *Also rod.*
[c] *B134 covers drawn flat wire. Compositions are applicable to other drawn flat products.*

IN PLANT of Titan Metal Manufacturing Co. brass rod is hot extruded before drawing into wire for the production of cold-headed parts.



FIRST STAGE in the production of 105-mm shell from cartridge brass is a cupping operation. (U.S. Army)

# Engineering Properties

### Physical properties

Some of the physical properties of the non-leaded brasses are given in an accompanying table. The temperature at which melting starts decreases with increasing zinc content, a factor which must be considered in any operation involving working at elevated temperatures.

The thermal and electrical conductivities decrease also with increasing zinc content through the alpha-range but there is a reversal when the second phase appears. Muntz metal has practically the same conductivity as cartridge brass. On the other hand there is a progressive increase in thermal expansion coefficients with rise in zinc content, while the specific heat can be considered constant for all of these alloys.

Since these brasses are frequently used in decorative applications, color is an important property. The selection of the name *gilding, 95%* is based on the color of the alloy. Bronze shading into a color similar to gold persists from 95% to 85% copper; at 80%, the color is distinctly yellow. The characteristic color of brass occurs at 70% copper; at

**TABLE 4—TYPICAL PHYSICAL PROPERTIES**

| Designation | Melting Range | | Density lb/cu in. at 68 F | Sp Gr | Coef of Ther Exp/F 68-572 F | Ther Cond Btu/sq ft/ ft/hr/F at 68 F | Elect Cond, % I.A.C.S. at 68 F | Spec Ht Btu/lb/F at 68 F | Mod of Elast, psi | Mod of Rigidity, psi |
|---|---|---|---|---|---|---|---|---|---|---|
| | Liquidus, F | Solidus, F | | | | | | | | |
| Gilding, 95% | 1950 | 1920 | 0.320 | 8.86 | $10.0 \times 10^{-6}$ | 135 | 56 | 0.09 | 17,000,000 | 6,400,000 |
| Commercial Bronze, 90% | 1910 | 1870 | 0.318 | 8.80 | $10.2 \times 10^{-6}$ | 109 | 44 | 0.09 | 17,000,000 | — |
| Red Brass, 85% | 1880 | 1810 | 0.316 | 8.75 | $10.4 \times 10^{-6}$ | 92 | 37 | 0.09 | 17,000,000 | — |
| Low Brass, 80% | 1830 | 1770 | 0.313 | 8.67 | $10.6 \times 10^{-6}$ | 81 | 32 | 0.09 | 16,000,000 | — |
| Cartridge Brass, 70% | 1750 | 1680 | 0.308 | 8.53 | $11.1 \times 10^{-6}$ | 70 | 28 | 0.09 | 16,000,000 | — |
| Yellow Brass | 1710 | 1660 | 0.306 | 8.47 | $11.3 \times 10^{-6}$ | 67 | 27 | 0.09 | 15,000,000 | — |
| Muntz Metal | 1660 | 1650 | 0.303 | 8.39 | $11.6 \times 10^{-6}$ | 71 | 28 | 0.09 | 15,000,000 | 5,600,000 |

40%, a reversal occurs and the color of Muntz metal is similar to red brass, 85%.

### Mechanical properties

The mechanical properties of the work-hardening copper alloys are determined by the degree of annealing or by the cold-working which has been performed after annealing. In the brass industry, the condition resulting is called *temper*.

Present practice is to indicate the degree of anneal for alpha alloys by the size of the grain. The commonly specified nominal annealed tempers are 0.015 mm, 0.025 mm, 0.035 mm, 0.050 mm, 0.070 mm and 0.120 mm grain size. In general the larger the grain, the softer the material.

As an example, the tensile strength of yellow brass annealed to 0.070 mm grain size is 46,000 psi and the hardness is Rockwell F-58. The same material annealed to 0.015 mm grain size has a tensile strength of 53,000 psi and a hardness of Rockwell F-78.

Muntz metal, which is a two phase alloy, cannot be classified by this system and the terms light anneal and soft anneal are used commonly for this material. Light anneal is roughly equivalent to 0.025 mm and soft anneal corresponds approximately to 0.070 mm grain size.

The tempers of cold-worked material are generally specified by such terms as half hard, spring and so forth. However, attempts are being made to specify the degree of cold work more exactly by giving the actual reduction in percent. An accompanying table gives the approximate relationship between temper and percent reduction.

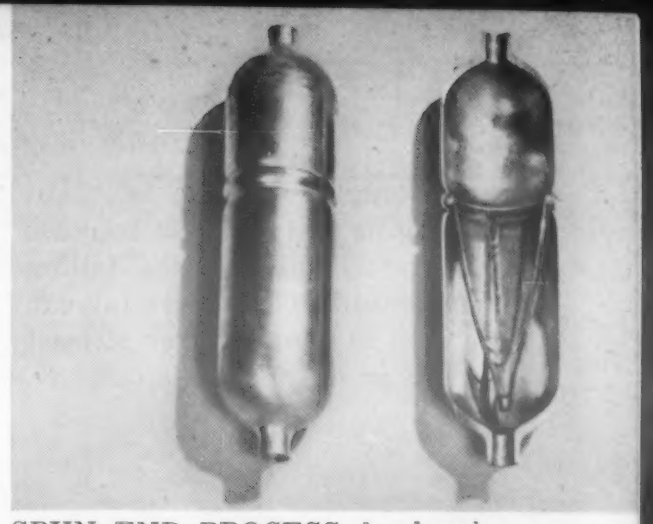
Typical mechanical properties of the brasses are given in the table. Values for annealed flat products are shown as ranges to indicate the variation which can be expected with material annealed to different grain sizes. As mentioned above, the higher values of strength and hardness and the lower values of elongation apply to the finer grain material. The table shows that in annealed material, the strength increases with zinc content. However, ductility as measured by elongation does not follow a pattern of progressive decrease with increasing strength. Greatest ductility is shown by alloys in the range included between cartridge brass, 70% and yellow brass. With the appearance of the second phase, ductility drops markedly and Muntz metal, for example, has only fair cold-working properties.

The effects of cold working on strength and ductility of these alloys are indicated also in the table. Strengths increase with degree of cold work and with zinc content. Ductility falls correspondingly as indicated by the differences in elongation between annealed and half hard metal. The elongation of gilding, 95%, commercial bronze, 80%, red brass, 85% and Muntz metal falls from about 45% for annealed material to 11% for half hard material. For low brass, 80% elongation falls from about 50% to 18% while for cartridge brass, 70% and yellow brass, the corresponding drop is from 65 to 23%.

The shear strengths of brasses are about 70% of the tensile strengths for annealed metal and 60% for cold-worked material. As a very rough approximation, the endurance strengths of these brasses in both annealed and cold-worked conditions can be taken as 25 to 30% of the tensile strength.

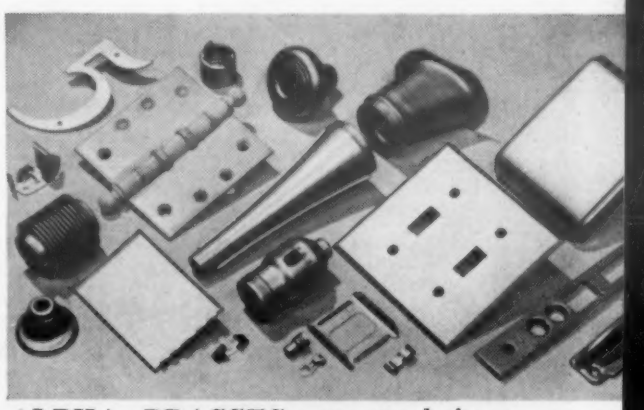
**TABLE 5—RELATIONSHIP BETWEEN TEMPER AND REDUCTION BY COLD-WORKING**

| Nominal Temper | Rolled Flat Products Approx Reduction in Thickness, % | Wire Approx Reduction of Area, % |
|---|---|---|
| Eighth Hard | 6 | 11 |
| Quarter Hard | 11 | 21 |
| Half Hard | 21 | 37 |
| Hard | 37 | 60 |
| Extra Hard | 50 | 75 |
| Spring | 60 | 84 |



SPUN END PROCESS developed by Wolverine permits production of necks, semi-closures or complete closures in low zinc brasses with simple tools.

EMBOSSED DESIGNS are used for production of consumer products from Red Brass, 85%. Finishing often includes gold or silver plating. (Eastern Brass & Copper Co.)



ALPHA BRASSES are used in production of various parts for the building construction, electrical and process industries. (Scovill Manufacturing Co.)

### Low and high temperature properties

Brasses retain their toughness at low temperatures and there is no indication of a transition

from tough to brittle behavior. Strengths and stiffness increase moderately also with falling temperature. These materials can be used to temperatures at least as low as —200 F satisfactorily.

The high temperature oxidation rates of the brasses are such that they are useful only at moderately elevated temperatures, in general not exceeding 500 F. The corrosion resistance of red brass, 85%, and its practical immunity to dezincification leads to its use at moderate temperatures in the petroleum and process industries, particularly in condensers and heat exchangers. Muntz metal is

**TABLE 6—TYPICAL MECHANICAL PROPERTIES**

| Designation | Section Size, in. | Temper | Ten Str, psi | Yld Str ½% extn under load, psi | Elong, % in 2 in. | Rockwell Hardness F | Rockwell Hardness B | Rockwell Hardness 30T | Shear Str, psi | Endurance Str psi | Endurance Str cycles |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FLAT PRODUCTS | | | | | | | | | | | |
| Gilding, 95% | 0.040 | Annealed[a] | 34,000–38,000 | 10,000–14,000 | 45–42 | 46–60 | — | 4–15 | 28,000–30,000 | — | — |
| | | Quarter Hard | 42,000 | 32,000 | 25 | — | 38 | 44 | 32,000 | — | — |
| | | Half Hard | 48,000 | 40,000 | 12 | — | 52 | 54 | 34,000 | — | — |
| | | Hard | 56,000 | 50,000 | 5 | — | 64 | 60 | 37,000 | — | — |
| | | Extra Hard | 61,000 | 55,000 | 4 | — | 70 | 64 | 39,000 | — | — |
| | | Spring | 64,000 | 58,000 | 4 | — | 73 | 66 | 40,000 | — | — |
| Commercial Bronze, 90% | 0.040 | Annealed[a] | 37,000–41,000 | 10,000–15,000 | 45–42 | 53–65 | — | 6–26 | 28,000–32,000 | — | — |
| | | As Hot Rolled | 39,000 | 14,000 | 44 | 60 | — | — | 31,000 | — | — |
| | | Quarter Hard | 45,000 | 35,000 | 25 | — | 42 | 44 | 33,000 | — | — |
| | | Half Hard | 52,000 | 45,000 | 11 | — | 58 | 56 | 35,000 | — | — |
| | | Hard | 61,000 | 54,000 | 5 | — | 70 | 63 | 38,000 | — | — |
| | | Extra Hard | 67,000 | 58,000 | 4 | — | 75 | 67 | 40,000 | — | — |
| | | Spring | 72,000 | 62,000 | 3 | — | 78 | 69 | 42,000 | 21,000 | $1.5 \times 10^7$ |
| Red Brass, 85% | 0.040 | Annealed[a] | 39,000–45,000 | 10,000–18,000 | 48–42 | 56–71 | — | 10–38 | 31,000–33,000 | — | — |
| | | Quarter Hard | 50,000 | 39,000 | 25 | — | 55 | 54 | 35,000 | — | — |
| | | Half Hard | 57,000 | 49,000 | 12 | — | 65 | 60 | 37,000 | — | — |
| | | Hard | 70,000 | 57,000 | 5 | — | 77 | 68 | 42,000 | — | — |
| | | Extra Hard | 78,000 | 61,000 | 4 | — | 83 | 72 | 44,000 | — | — |
| | | Spring | 84,000 | 63,000 | 3 | — | 86 | 74 | 46,000 | — | — |
| Low Brass, 80% | 0.040 | Annealed[a] | 42,000–50,000 | 12,000–20,000 | 52–46 | 57–75 | — | 8–42 | 32,000–33,000 | — | — |
| | | Quarter Hard | 53,000 | 40,000 | 30 | — | 55 | 54 | 36,000 | — | — |
| | | Half Hard | 61,000 | 50,000 | 18 | — | 70 | 64 | 39,000 | — | — |
| | | Hard | 74,000 | 59,000 | 7 | — | 82 | 71 | 43,000 | — | — |
| | | Spring | 91,000 | 65,000 | 3 | — | 91 | 77 | 48,000 | 24,000 | $2 \times 10^7$ |
| Cartridge Brass, 70% | 0.040 | Annealed[a] | 44,000–53,000 | 11,000–22,000 | 66–54 | 54–78 | — | 11–43 | 32,000–35,000 | 13,000–15,000 | $10^8$ |
| | | Quarter Hard | 54,000 | 40,000 | 43 | — | 55 | 54 | 36,000 | — | — |
| | | Half Hard | 62,000 | 52,000 | 23 | — | 70 | 63 | 40,000 | 18,000 | $10^8$ |
| | | Hard | 76,000 | 63,000 | 8 | — | 82 | 73 | 44,000 | 21,000 | $10^8$ |
| | | Extra Hard | 86,000 | 65,000 | 5 | — | 88 | 76 | 46,000 | — | — |
| | | Spring | 94,000 | 65,000 | 3 | — | 91 | 77 | 48,000 | 23,000 | $10^8$ |
| | | Extra Spring | 99,000 | 65,000 | 3 | — | 93 | 78 | — | — | — |
| Yellow Brass | 0.040 | Annealed[a] | 46,000–53,000 | 14,000–22,000 | 65–54 | 58–78 | — | 15–43 | 32,000–34,000 | 12,000 | $10^8$ |
| | | Eighth Hard | 50,000 | 35,000 | 50 | — | 50 | 50 | — | — | — |
| | | Quarter Hard | 54,000 | 40,000 | 43 | — | 55 | 54 | 36,000 | — | — |
| | | Half Hard | 61,000 | 50,000 | 23 | — | 70 | 65 | 40,000 | — | — |
| | | Hard | 74,000 | 60,000 | 8 | — | 80 | 70 | 43,000 | 14,000 | $10^8$ |
| | | Extra Hard | 85,000 | 62,000 | 5 | — | 87 | 74 | 45,000 | — | — |
| | | Spring | 91,000 | 62,000 | 3 | — | 90 | 76 | 47,000 | 20,000 | $10^8$ |
| Muntz Metal | 0.040 | Soft Anneal | 54,000 | 21,000 | 45 | 80 | — | 46 | 40,000 | — | — |
| | | As Hot Rolled | 54,000 | 21,000 | 45 | 85 | — | 49 | 40,000 | — | — |
| | | Eighth Hard | 60,000 | 35,000 | 30 | — | 55 | 54 | 42,000 | — | — |
| | | Half Hard | 70,000 | 50,000 | 10 | — | 75 | 67 | 44,000 | — | — |
| ROD | | | | | | | | | | | |
| Commercial Bronze, 90% | 0.5 | 0.035 mm[b] | 40,000 | — | 50 | 55 | — | — | 32,000 | — | — |
| | | Eighth Hard | 45,000 | — | 25 | — | 42 | — | 33,000 | — | — |
| Cartridge Brass, 70% | 1.0 | 0.050 mm[b] | 48,000 | 16,000 | 65 | 65 | — | — | 34,000 | — | — |
| | | Eighth Hard | 55,000 | 40,000 | 48 | — | 60 | — | 36,000 | — | — |
| | | Half Hard | 70,000 | 52,000 | 30 | — | 80 | — | 42,000 | 22,000 | $5 \times 10^7$ |
| Yellow Brass | 1.0 | 0.050 mm[b] | 48,000 | 16,000 | 65 | 65 | — | — | 34,000 | — | — |
| | | Eighth Hard | 55,000 | 40,000 | 48 | — | 55 | — | 36,000 | — | — |
| Muntz Metal | 1.0 | Soft Anneal | 54,000 | 21,000 | 50 | 80 | — | — | 40,000 | — | — |
| | | Quarter Hard | 72,000 | 50,000 | 25 | — | 78 | — | 45,000 | — | — |
| | | As Extruded | 52,000 | 20,000 | 52 | 78 | — | — | 39,000 | — | — |

[a] *The properties of annealed material vary with the grain size (see text).*
[b] *Annealed to grain size indicated.*

**TABLE 6—TYPICAL MECHANICAL PROPERTIES—(Continued)**

| Designation | Section Size, in. | Temper | Ten Str, psi | Yld Str ½% extn under load, psi | Elong, % in 2 in. | Rockwell Hardness F | Rockwell Hardness B | Rockwell Hardness 30T | Shear Str, psi | Endurance Str psi | Endurance Str cycles |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WIRE | | | | | | | | | | | |
| Commercial Bronze, 90% | 0.080 | Annealed[a] | 40,000–42,000 | — | 50–48 | — | — | — | 30,000–32,000 | — | — |
| | | Eighth Hard | 44,000 | — | 27 | — | — | — | 33,000 | — | — |
| | | Quarter Hard | 50,000 | — | 13 | — | — | — | 34,000 | — | — |
| | | Half Hard | 60,000 | — | 6 | — | — | — | 37,000 | — | — |
| | | Hard | 74,000 | — | 4 | — | — | — | 42,000 | 23,000 | $10^8$ |
| | | Extra Hard | 83,000 | — | 3 | — | — | — | — | — | — |
| | | Spring | 90,000 | — | 3 | — | — | — | — | — | — |
| Red Brass, 85% | 0.080 | Annealed[a] | 41,000–45,000 | — | 48 | — | — | — | 31,000–33,000 | — | — |
| | | Eighth Hard | 50,000 | — | 25 | — | — | — | 35,000 | 20,000 | $3 \times 10^8$ |
| | | Quarter Hard | 59,000 | — | 11 | — | — | — | 38,000 | — | — |
| | | Half Hard | 72,000 | — | 8 | — | — | — | 43,000 | — | — |
| | | Hard | 88,000 | — | 6 | — | — | — | 48,000 | — | — |
| | | Spring | 105,000 | — | — | — | — | — | 54,000 | — | — |
| Low Brass, 80% | 0.080 | Annealed[a] | 44,000–50,000 | — | 55–47 | — | — | — | 32,000–33,000 | — | — |
| | | Eighth Hard | 56,000 | — | 27 | — | — | — | 37,000 | — | — |
| | | Quarter Hard | 68,000 | — | 12 | — | — | — | 42,000 | — | — |
| | | Half Hard | 82,000 | — | 8 | — | — | — | 47,000 | — | — |
| | | Hard | 107,000 | — | 5 | — | — | — | 53,000 | 23,000 | $10^8$ |
| | | Extra Hard | 116,000 | — | 4 | — | — | — | — | — | — |
| | | Spring | 125,000 | — | 3 | — | — | — | 60,000 | 26,000 | $10^8$ |
| Cartridge Brass, 70% | 0.080 | Annealed[a] | 48,000–54,000 | — | 64–56 | — | — | — | 34,000 | — | — |
| | | Eighth Hard | 58,000 | — | 35 | — | — | — | 38,000 | — | — |
| | | Quarter Hard | 70,000 | — | 20 | — | — | — | — | — | — |
| | | Extra Hard | 124,000 | — | 4 | — | — | — | — | — | — |
| | | Spring | 130,000 | — | 3 | — | — | — | 60,000 | 22,000 | $10^8$ |
| Yellow Brass | 0.080 | 0.035 mm[b] | 50,000 | — | 60 | — | — | — | 34,000 | — | — |
| | | Eighth Hard | 58,000 | — | 35 | — | — | — | 38,000 | — | — |
| | | Quarter Hard | 70,000 | — | 20 | — | — | — | 42,000 | 22,000 | $3 \times 10^8$ |
| | | Half Hard | 88,000 | — | 15 | — | — | — | — | — | — |
| | | Hard | 110,000 | — | 8 | — | — | — | 55,000 | — | — |
| | | Extra Hard | 120,000 | — | 4 | — | — | — | — | — | — |
| | | Spring | 128,000 | — | 3 | — | — | — | 60,000 | — | — |
| TUBE | | | | | | | | | | | |
| Commercial Bronze, 90% | 1.0 O.D. x 0.065 | 0.035 mm[b] | 38,000 | 12,000 | 50 | 57 | — | 12 | — | — | — |
| | | Hard Drawn | 60,000 | 53,000 | 6 | — | 69 | 62 | — | — | — |
| Red Brass, 85% | 1.0 O.D. x 0.065 | Annealed[a] | 40,000–44,000 | 12,000–18,000 | 55–45 | 60–71 | — | 15–38 | — | — | — |
| | | Light Drawn | 50,000 | 40,000 | 30 | — | 55 | 54 | — | — | — |
| | | Hard Drawn | 70,000 | 58,000 | 8 | — | 77 | 68 | — | — | — |
| Cartridge Brass, 70% | 1.0 O.D. x 0.065 | Annealed[a] | 47,000–52,000 | 15,000–20,000 | 65–55 | 64–75 | — | 26–40 | — | — | — |
| | | Hard Drawn | 78,000 | 64,000 | 8 | — | 82 | 73 | — | — | — |
| Muntz Metal | 1.0 O.D. x 0.065 | Light Anneal | 56,000 | 23,000 | 50 | 82 | — | 47 | — | — | — |
| | | Hard Drawn | 74,000 | 55,000 | 10 | — | 80 | — | — | — | — |
| PIPE | | | | | | | | | | | |
| Red Brass, 85% | 0.75 | 0.015 mm[b] | 44,000 | 18,000 | 45 | 71 | — | — | — | — | — |

[a] *The properties of annealed material vary with the grain size (see text).*
[b] *Annealed to grain size indicated.*

also used frequently in this service in spite of its susceptibility to dezincification, the thickness of the material being selected to give reasonable service life.

The Unfired Pressure Vessel Code of the ASME is an excellent reference for temperature and stress limitations. This code specifies that the maximum allowable stress for red brass, 85% be 6000 psi for metal temperatures not exceeding 350 F, 3000 psi for 400 F and 2000 psi for 450 F. No higher temperatures are covered. For Muntz metal, the maximum allowable stress is 7500 psi at 350 F and 2000 psi at 400 F. No higher temperatures are covered.

### Corrosion resistance

In addition to the usual forms of corrosive attack, certain of the brasses are susceptible to dezincification. Stress-corrosion cracking can occur in brasses also.

Dezincification is a type of corrosion in which the brass dissolves as an alloy, the copper redeposits in a porous form and the zinc is either removed as a soluble salt or deposited as an insoluble zinc compound. When dezincification occurs under strongly acid conditions, it proceeds uniformly. In alkaline, neutral or slightly acid solutions, localized or plug-type dezincification will

**TABLE 7—APPROXIMATE CORROSION RESISTANCE**

| GOOD | | FAIR | | POOR | |
|---|---|---|---|---|---|
| Low Zinc Brass | High Zinc Brass | Low Zinc Brass | High Zinc Brass | Low Zinc Brass | High Zinc Brass |
| Acetic Acid | Ammonia, dry | Ammomium sulfate | Carbon dioxide, moist | Ammonia, moist | Acetic acid |
| Ammonia, dry | Atmosphere, industrial, marine, rural | Chlorine, moist | Hydrogen sulfide, moist | Ammonium hydroxide | Ammonia, moist |
| Atmosphere, industrial, marine, rural | Carbon dioxide, dry | Copper chloride | Potassium chloride | Ammonium chloride | Ammonium hydroxide |
| Calcium chloride | Chlorine, dry | Hydrochloric acid | Potassium hydroxide | Chromic acid | Ammonium chloride |
| Carbon dioxide | Hydrogen | Hydrofluoric acid | Sodium chloride | Ferric chloride | Ammonium sulfate |
| Chlorine, dry | Hydrogen sulfide, dry | Phosphoric acid | Water, fresh, sea | Ferric sulfate | Calcium chloride |
| Copper sulfate | Potassium sulfate | Potassium hydroxide | — | Hydrogen sulfide, moist | Chlorine, moist |
| Ferrous chloride | Sodium sulfate | Sodium hydroxide | — | Mercury salts | Chromic acid |
| Ferrous sulfate | Sulfur dioxide, dry | Sulfuric acid | — | Nitric acid | Copper chloride |
| Hydrogen | — | Zinc chloride | — | Sodium cyanide | Copper sulfate |
| Hydrogen sulfide, dry | — | — | — | — | Ferrous and Ferric chloride |
| Potassium chloride | — | — | — | — | Ferrous and Ferric sulfate |
| Potassium sulfate | — | — | — | — | Hydrochloric acid |
| Sodium chloride | — | — | — | — | Hydrofluoric acid |
| Sodium sulfate | — | — | — | — | Mercury salts |
| Sulfur dioxide | — | — | — | — | Nitric acid |
| Sulfurous acid | — | — | — | — | Sodium hydroxide |
| Water, fresh, sea | — | — | — | — | Sulfur dioxide, moist |
| — | — | — | — | — | Sulfuric acid |
| — | — | — | — | — | Sulfurous acid |
| — | — | — | — | — | Zinc chloride |

*Good indicated usable under most conditions.*
*Fair indicates subject to attack but may be used under certain conditions.*
*Poor indicates unsuitable.*

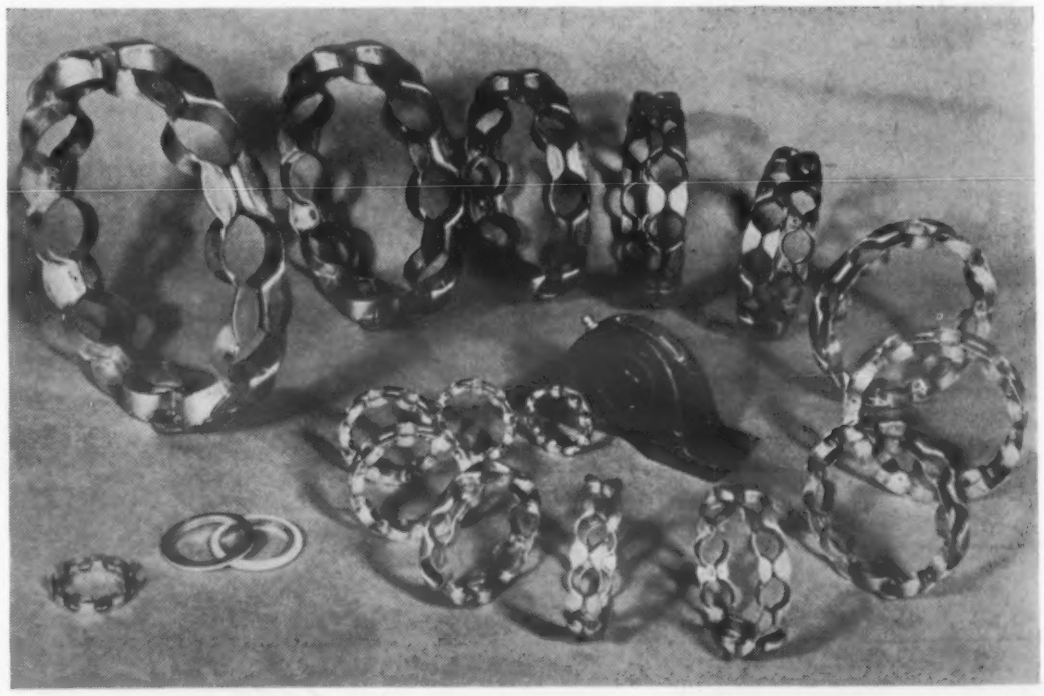
occur. High temperatures and low velocity of the corroding medium accelerate corrosion by dezincification. Not all brasses are susceptible to this type of attack. Those containing 85% or more copper are highly resistant while certain of the alloy brasses, particularly those containing arsenic, antimony or phosphorus, are more resistant than the plain brasses.

Stress-corrosion or season cracking results from the combined action of localized corrosion and stress. The stress can be the result of cold deformation or may exist because of an external load. Presence of moist ammonia in the air is considered to be the major cause of stress corrosion cracking. Brasses containing less than 85% copper are more prone to this type of attack than other copper alloys. A stress relieving heat treatment can be used to remove residual stresses and prevent season cracking resulting from cold working.

Copper alloys are attacked rapidly by oxidizing acids such as nitric but the rate of attack by other acids depends on the presence of an oxidizing agent. Brasses containing not more than 15% zinc offer good resistance to hot and cold dilute sulfuric and cold concentrated sulfuric, although intermediate concentrations can be more corrosive. These brasses also resist hydrochloric acid at room temperature and can handle many organic acids. High zinc brasses should not be used with acids because of the possibility of dezincification.

Of the alkalies, sodium and potassium hydroxides can be handled in brass equipment providing the zinc content is not more than 15%. Dezincification can occur in plain brasses containing greater quantities of zinc. Moist ammonia, particularly in the presence of air, attacks brasses, especially those containing more than 15% zinc.

Alkaline salts such as sodium carbonate are less corrosive than



CARTRIDGE BRASS STRIP is used in the production of many industrial parts including these ball bearing retainers. (Revere Copper and Brass, Inc.)

hydroxides. Neutral salts are frequently handled in brasses in which copper content is 85% or higher. Salts which hydrolize to form acids, especially those having oxidizing properties are particularly corrosive. Mercury and mercury salts cannot be handled in copper alloys. As a matter of fact, mercurous nitrate is used as an accelerated test to determine the presence of internal stress.

Some idea of the differences in resistance to corrosive attack between low-zinc brasses and high-zinc brasses can be obtained by referring to an accompanying table. In this table, an estimate is made of the relative resistance of the two types of brass to attack by a group of corroding media. It should be emphasized that this table is only an indication of rates of attack. There are so many factors involved in selecting a material for service under corrosive conditions that the only satisfactory procedure is a service test.

# Processing Characteristics

### Forming and fabricating

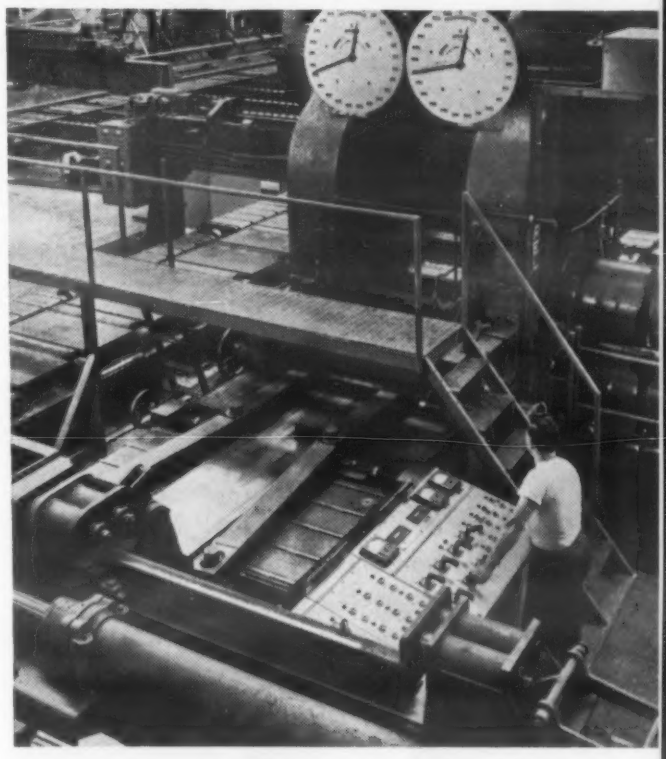
The brasses can be divided, as mentioned, into cold working and hot working materials. The alpha brasses fall into the former classification while the duplex brasses fall into the latter.

*Cold Working*—Because of the balanced combination of strength and ductility, cartridge brass, 70% can be worked cold more severely in a single operation than the other brasses. However, this does not imply that cartridge brass, 70% is more ductile than the higher copper-content brasses. Gilding, 95% and commercial bronze, 90%, for example, can stand a greater total cold reduction than cartridge brass before annealing is required, if the operation is performed in a number of stages.

In forming, such as deep drawing and other severe operations, grain size is an important consideration and annealed metal specified by grain size is generally employed. In stretching operations, the roughened surface known as "orange peel" appears at a grain size of about 0.030 to 0.040 mm and increases rapidly with increasing grain size. Removal of the rough surface can require extensive finishing operations.

A recent development in the brass industry is the production of brasses with controlled superfine grain. These brasses can be worked readily although greater power is required than necessary for the usual types. They have the advantage of requiring less finishing operations.

*Bending* — In bending, the allowable deformation depends on the gage, temper, direction and radius of the bend. The more severe the forming required, the less prior cold-working can be tolerated. The lowest ductility lies across the direction of rolling and in rolled tempers severe bends in that di-



SCOVILL REDUCES brass bars from 2.5 to 0.4 in. in thickness in this 2-Hi cold rolling mill.

**TABLE 8—FABRICATING PROPERTIES**

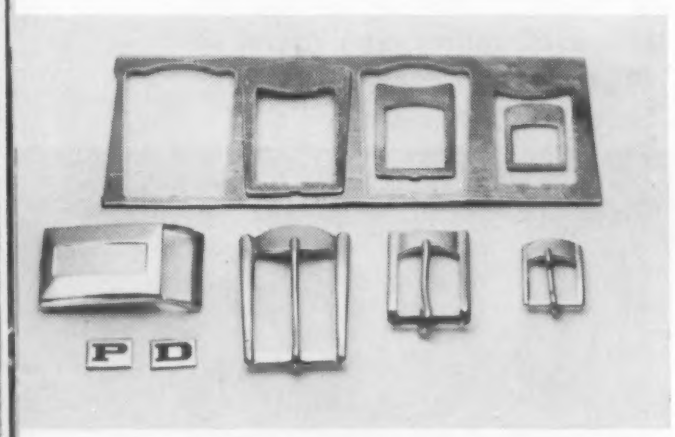
| Designation | Cold Working | Hot Working | Hot Working Temp Range, F | Annealing Temp Range, F | Machinability Rating* |
|---|---|---|---|---|---|
| Gilding, 95% | Excellent | Good | 1400–1600 | 800–1450 | 20 |
| Commercial Bronze, 90% | Excellent | Good | 1400–1600 | 800–1450 | 20 |
| Red Brass, 85% | Excellent | Good | 1450–1650 | 800–1350 | 30 |
| Low Brass, 80% | Excellent | Fair | 1500–1650 | 800–1300 | 30 |
| Cartridge Brass, 70% | Excellent | Fair | 1350–1550 | 800–1400 | 30 |
| Yellow Brass | Excellent | Poor | — | 800–1300 | 30 |
| Muntz Metal | Fair | Excellent | 1150–1450 | 800–1100 | 40 |

*Free-cutting brass = 100*

**TABLE 9—OPTIMUM GRAIN SIZE FOR CARTRIDGE BRASS, 70% AND YELLOW BRASS**

| Nominal Grain Size, mm | Typical Application |
|---|---|
| 0.015 | Slight forming operations |
| 0.025 | Shallow drawing |
| 0.035 | Drawing to obtain best average surface condition |
| 0.050 | Deep drawing |
| 0.100 | Deep drawing of heavy gage material |

BRASS ANNEALED to exceptionally fine grain sizes is used for forming decorative articles such as this military brush back. The improved surface obtained with such brass reduces number of finishing operations. (American Brass Co.)




SCRAP IS REDUCED to a minimum in production of brass buckles by blanking three sizes from same strip. The smallest buckle is blanked from inside of the middle one which, in turn is blanked from inside of the largest. (Connecticut Web & Buckle Co. and Bridgeport Brass Co.)

STAGES IN PRODUCTION of a cartridge brass part which has been drawn and formed with only two intermediate anneals. (Revere Brass and Copper, Inc.)

**TABLE 10—MINIMUM PERMISSIBLE BENDING RADII FOR 0.020-IN. STRIP (GOHN)***

| Temper | RED BRASS, 85% | | LOW BRASS, 80% | | CARTRIDGE BRASS, 70% | | YELLOW BRASS | |
|---|---|---|---|---|---|---|---|---|
| | Hard | Spring | Hard | Spring | Hard | Spring | Hard | Spring |
| Across the Grain | Sharp | 1/64 in. | 1/32 in. | 1/32 in. | 1/64 in. | 3/64 in. | Sharp | Sharp |
| With the Grain | 1/64 in. | 7/32 in. | 1/16 in. | 3/16 in. | 1/32 in. | 7/32 in. | 1/32 in. | 1/32 in. |

* *Proc. ASTM Vol 36, 1936 II, p 207.*

rection are limited. It is often possible to blank the strip in a direction permitting the more severe bends to be made parallel to or at a 45-deg angle with the rolling direction, however.

Grain size is also important. Bending changes the temper of the part only locally at the bend but in operations involving drastic bending, use of coarse-grained stock may result in the formation of "orangepeel" in that area and increase the expense of finishing operations.

An accompanying table gives the minimum recommended bending radii for certain alloys and tempers. As a general rule 0.020-in. gage alpha brasses can be bent 90 deg in any direction in the half hard condition.

Although cold-worked brasses have tensile strength equivalent to those of mild steel, their moduli of elasticity are only about half those of steel. Where rigidity is a requirement the difference in moduli must be considered in designing.

*Deep Drawing* — Since cartridge brass, 70% can withstand severe single-stage cold working, it is widely used for deep drawing operations. However, the other alpha brasses are also deep drawn frequently.

In deep drawing, some organizations believe that the radius of curvature of the working shoulder of the die is important. They suggest that when working brass strip 1/64 to 1/32 in. thick, for example, the radius should be about ten times the metal thickness, while for thicker metal, the radius can be four to six times the thickness. In another organization, radius of the die is not considered too important excepting in drawing flanged cups. In this organization, initial die development is started with a ½-in. radius for drawing 1/32-in. strip, for example, and the radius is increased or decreased until the proper conditions are determined. The radius on the punch should be small, usually not exceeding 1/6 of the punch diameter for most operations; but for exceptionally deep draws, a larger radius is required. Clearance between punch and die determines the wall thickness of the part.

Cups having diameters slightly less than ½ the diameter of the blank can be drawn in one operation, a reduction of 50%. Deeper cups can be produced in redrawing operations with or without intermediate anneals depending on the total reduction required. A soap solution is often used as coolant and lubricant, such a solution having the advantage of ready removal from the drawn part.

For a deep-drawn article requiring several drawing operations, two draws on brass can usually produce a deeper product than three draws on steel. Further, brass can be drawn at rates of speed two to three times as great as those used for ferrous metals and with considerably less tool wear. This is particularly advantageous in automatic press operations.

Parts requiring only shallow drawing are frequently made from material which is moderately cold worked in order that desired strength will be obtained.

*Coining*—This operation, involving metal flow under pressure in closed dies is applied to the production of decorative articles, particularly medals and coins. Cold stamping is a related operation in which the impres-

sions are obtained by impact rather than as the result of pressure. Stamping is a less expensive operation than coining but is satisfactory for production of numerous parts on which less accuracy is required. Another similar operation is embossing which involves the formation of designs on sheet and strip without appreciable change in the thickness of the material.

*Spinning*—Spinning is a hand operation which requires considerable skill. The most common type of brass used in the production of spun shells is cartridge brass because of its combination of strength and ductility. However, all alpha-brasses can be spun quite readily, if suitable care is taken to avoid over-stretching.

An indication of the relative ease with which these brasses can be spun is obtained by comparison with copper which is the easiest of the copper-bearing materials to spin cold. One organization suggests that if annealed copper be assigned the arbitrary value of 100, cartridge brass, 70% and yellow brass are 95, low brass, 80% is 92, red brass, 85% is 86, commercial bronze, 90% is 84, gilding, 95% is 80 and Muntz metal is 45.

### Hot forming

Although the modern alpha-brasses are often sufficiently pure to be hot worked commercially, they are seldom used for hot-forming operations other than hot-rolling, extrusion, etc., excepting for the bending or dishing of thick sections. Of the alloys under discussion, only the duplex material, Muntz metal, is extensively hot worked in secondary operations.

The term forging as applied to brass generally refers to press-forging in close dies. Drop forging finds only limited applications in the brass industry.

Muntz metal has good hot working properties. If forging brass is given a rating of 100, Muntz metal rates 90 and is one of the more readily forged of the copper alloys. Temperature for forging varies with the alloy. For Muntz metal, 1400 F is optimum.

Commercial dimensional tolerances for Muntz metal forgings weighing up to 2 lb range from ± 0.008 to ± 0.015 in. depending on the type. The lower tolerances are held on solid forgings, the higher on long thin sections.

Muntz metal can also be hot-formed readily by bending, flaring, dishing and spinning.

### Powder metallurgy

Various small brass components are produced by powder metallurgy processes. Brass powder, of suitable composition, is compressed in a die to form a compact which is subsequently sintered. Depending on the accuracy required, the sintered compact may or may not be coined. Generally this procedure is limited to low brasses because of excessive zinc losses from high brasses during sintering.

### Heat treatment

These brasses cannot be hardened by heat treatment. However, heat treatments are employed for annealing and stress relieving.

Annealing consists of heating the alloy to, or somewhat above, the recrystallization temperature and holding for sufficient time to obtain complete recrystallization. After complete recrystallization, grain growth occurs with any increase in temperature. However, the increase in grain size is not proportional to the temperature rise but tends to accelerate.

The mechanical properties of the metal change with grain growth. Strength and hardness decrease while elongation increases. Holding for a longer period of time at a definite temperature increases grain size but this procedure is not so effective as raising the temperature.

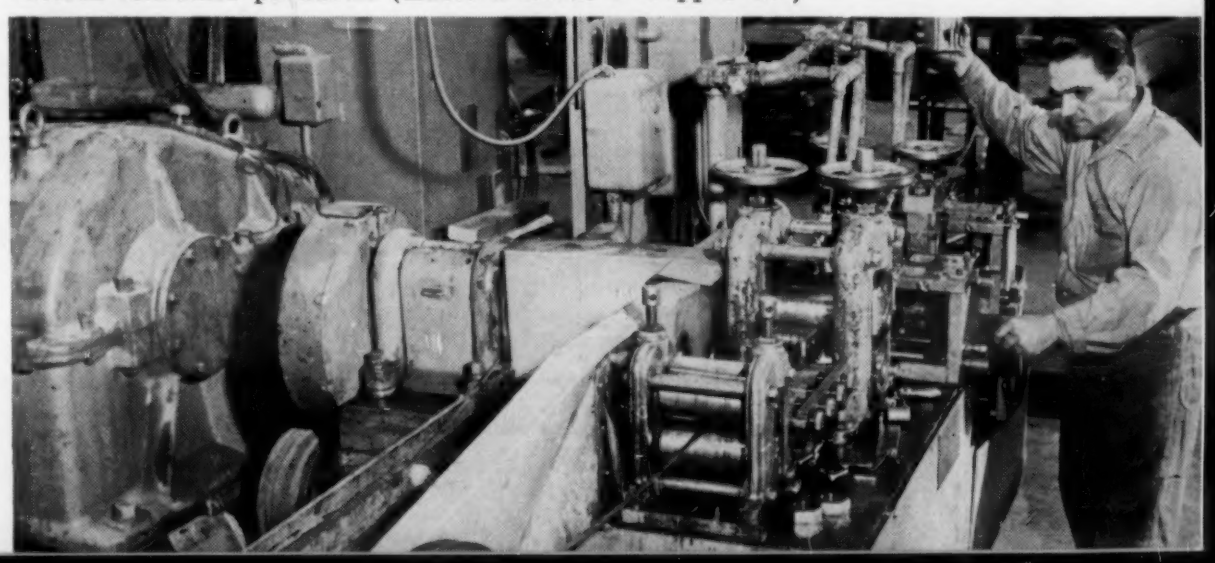
The condition of the metal also affects the grain size obtained on annealing. Increasing the degree of cold working lowers the recrystallization temperature, but the average annealed grain is larger, the smaller the amount of prior deformation. In copper-zinc alloys, increase in copper content over 65% also results in decreasing grain size.

The size of the average grain after annealing is the most accurate method of determining the degree of annealing. Hardness figures correlated with grain size are sometimes used however.

A stress-relief heat treatment is used to prevent season cracking from residual stresses resulting from working operations. Although sometimes referred to as "stress relief annealing", this term is rather misleading since there is no softening in material which has been stress relieved by heating to temperatures below the recrystallization temperature. Tensile strength and hardness are virtually unchanged by stress relieving although the elastic limit may be raised slightly.

The preferred practice is to use the lowest temperature for the longest time that is commercially practical; generally the temperature ranges from 400 to 600 F. The best method of selecting a suitable combination of temperature and time is the mercurous nitrate test which is

DECORATIVE DESIGNS are embossed on brass strip to be used for various consumer products. (Eastern Brass & Copper Co.)



covered in ASTM Designation B154.

Season cracking is more apt to occur in brasses containing more than 20% zinc than in those of lower zinc content.

### Machinability

There are no standard methods of determining the relative machinability of metals. Variables such as speed, feed, depth of cut, hardness and structure of the metal offer almost unlimited possibilities for removing a given quantity of metal in a definite time. For brasses, it is good practice to use the highest possible cutting speed, a relatively light feed and a moderate depth of cut. Although each alloy has its own characteristics, in general it can be stated that the optimum condition for machining these materials is obtained in the work hardened condition.

The relative machinability of copper alloys is determined by comparison with free-cutting brass. This is a leaded version of yellow brass in which the copper-zinc ratio is changed by reducing the copper content to 62% and adding 3% lead. It has the best machinability of the copper alloys, is given a rating of 100 and serves as a standard of comparison for the nonferrous metals.

Based on this standard, gilding, 95%, and commercial bronze, 90% are rated at 20 and have machinability characteristics similar to copper. The higher zinc brasses from red brass, 85% to yellow brass have machinability ratings of 30 and Muntz metal has a rating of 40. Brasses with ratings of 30 to 40 fall into the group which is considered to be readily machinable. Ratings are arbitrary but give a reasonable guide to relative tool life and power required for cutting. However, there is no clear-cut line of demarcation between groups and under different conditions, an alloy can shift from one group to another.

In turning operations, gilding, 95% and commercial bronze, 90% require relatively large rake angles. Side rakes frequently exceed those for steel. For the other brasses, considerably reduced rake angles are satisfactory. Suggested values are given in the table. Cutting edge angles, however, vary with the nature of the operation. Speeds can be considerably higher in machining the higher zinc brasses than those used for gilding and commercial bronze.

Standard straight blade high speed steel cut-off tools and many commercial milling cutters are suitable for use with brasses. Coarse-tooth spiral cutters with a helix angle of 20 to 30 deg and helical cutters with a helix angle up to 50 deg produce fine finishes on both groups of brasses. The clearance angle should be greater for small than for large cutters, the maximum angles suggested in the table being for cutters 3 to 4 in. in diameter.

For limited production, standard twist drills are satisfactory for use with the higher zinc brasses but the points should be ground as suggested in the table for drilling gilding, 95% and commercial bronze, 90%. High speed steel drills of special design are used frequently for long run operations. These drills have a greater number of twists per inch than the standard drills and the increased rake angle assists in removal of the chips.

Although some machining operations on the brasses are performed dry, use of a coolant is generally required to obtain finer finishes at higher speeds and feeds. For the higher zinc brasses, a water soluble oil is desirable when machining at high speeds. A mineral oil containing 5 to 15% lard oil has also been suggested. For the brasses containing more than 90% copper, a mineral oil containing 10 to 20% lard oil is satisfactory.

### Joining

All of these brasses can be

**TABLE 11—SUGGESTIONS FOR MACHINING[a]**

| OPERATION | SPEED, surface ft/min | | FEED, in./rev | | TOOL ANGLES, deg | |
|---|---|---|---|---|---|---|
| | Gilding, 95% and Commercial Bronze, 90% | Other Non-Leaded Brasses | Gilding, 95% and Commercial Bronze, 90% | Other Non-Leaded Brasses | Gilding, 95% and Commercial Bronze, 90% | Other Non-Leaded Brasses |
| Turning | 75–150<br>—<br>—<br>— | 150–300<br>—<br>—<br>— | Roughing 0.015–0.040<br>Finishing 0.005–0.020<br>—<br>— | Roughing 0.015–0.035<br>Finishing 0.005–0.015<br>—<br>— | Side rake 20–30<br>Back rake 10–20<br>Side clearance 10–20<br>Front clearance 10–15 | Side rake 5–10<br>Back rake 5–10<br>Side clearance 5–10<br>Front clearance 6–15 |
| Parting | 75–150<br>—<br>—<br>— | 150–300<br>—<br>—<br>— | 0.0005<br>—<br>—<br>— | 0.0015<br>—<br>—<br>— | End cutting edge 25<br>Back rake 7–15<br>Side clearance 2–4<br>Front clearance 5–10 | End cutting edge 15<br>Back rake 3–7<br>Side clearance 2–4<br>Front clearance 5–10 |
| Milling | 50–150<br>— | 150–200<br>— | 0.015–0.030[b]<br>— | 0.015–0.030[b]<br>— | Rake 0–15<br>Clearance 5–15 | Rake 0–10<br>Clearance 5–15 |
| Drilling | 50–125<br>—<br>— | 75–250<br>—<br>— | —<br>—<br>— | —<br>—<br>— | Clearance 12–20<br>Drill point 100–110<br>Cutting edge full rake | Clearance 12–15<br>Drill point 118<br>Cutting edge flattened to 0-deg rake |

[a] *Using high speed steel tools.*
[b] *Varies with such factors as cutter width, feed rate which also may vary, desired finish*

joined easily by soldering and brazing but certain characteristics of the materials must be given consideration in welding procedures.

*Soldering*—Although not so readily soldered as copper, the brasses are much easier to solder than ferrous metals. Solder containing 60% tin gives best results but the 50-50 grade can be used. For optimum joint strength antimony content of the solder must be held below ½%, because antimony and zinc can combine to form a brittle compound. Surfaces to be joined must be cleaned by pickling or abrasion. However, brasses inhibited with antimony or arsenic should not be pickled because these elements form oxides which cover the surface and interfere with "wetting". The strongest joints are obtained if acid fluxes which are usually mixtures of zinc and ammonium chlorides are used.

Before soldering high zinc brasses, which have been stressed in previous operations, the brasses should be given the stress relief heat treatment described previously. Unless stresses are relieved, the solder may penetrate the metal and cause cracking. As an additional precaution, no stresses should be applied to the assembly while the solder is molten.

*Brazing*—Low zinc brasses can be brazed with either copper-zinc brazing alloys or with silver brazing alloys. Because of their low melting points, however, high zinc brasses must be joined with silver brazing alloys which have melting points below about 1400 F.

Generally, joints are made by flowing molten filler metal into close fitting joints of the components by capillarity. Although any heating method can be used, care is necessary to prevent localized overheating which can cause cracking. Regardless of the type of filler metal used, a flux is necessary. Fluxes based on borax and boric acid are used with brass brazing alloys while proprietary fluxes containing fluorides are commonly used with the silver brazing alloys.

**TABLE 12—SUITABILITY OF JOINING METHODS**

| Designation | Soldering | Silver Alloy Brazing | Carbon Arc Welding | Metal Arc Welding | Resistance Welding | Oxy-Acetylene Welding |
|---|---|---|---|---|---|---|
| Gilding, 95% | Excellent | Excellent | Good | Good | Poor | Fair |
| Commercial Bronze, 90% | Excellent | Excellent | Good | Fair | Poor | Good |
| Red Brass, 85% | Excellent | Excellent | Good | Fair | Poor | Good |
| Low Brass, 80% | Excellent | Good | Fair | Poor | Poor | Good |
| Cartridge Brass, 70% | Excellent | Good | Fair | Poor | Fair | Good |
| Yellow Brass | Excellent | Good | Fair | Poor | Fair | Good |
| Muntz Metal | Excellent | Good | Fair | Poor | Fair | Good |

*Welding*—A number of welding procedures are used for joining the brasses but there are certain factors which must be taken into account. Because of their relatively high electrical conductivity, the low zinc brasses are more difficult to join by resistance welding than the high zinc brasses.

In carbon-arc welding of the low zinc brasses, zinc free rods such as copper-silicon or copper-tin are generally used, the former being preferred for multi-pass welds. For high zinc brasses the copper-silicon rod with a suitable flux is usually used. Preheating to about 400 F is necessary to assure a sound weld. Welding high zinc brasses requires consideration of the volatility of zinc in order to minimize losses by evaporation. In addition, zinc vapor readily oxidizes in air to form dense white fumes which not only interfere with the operator by obscuring his vision but also are harmful. Adequate ventilation is required in welding these alloys and a respirator should be worn by the operator. Brasses containing more than 15% zinc should be stress relieved to prevent subsequent stress corrosion.

Shielded metal-arc welding requires the use of either phosphor bronze or aluminum bronze coated electrodes, the latter giving the stronger joint. Preheating is necessary for best results. Generally, welding is performed with dc reversed polarity, although aluminum bronze electrodes are available for ac welding.

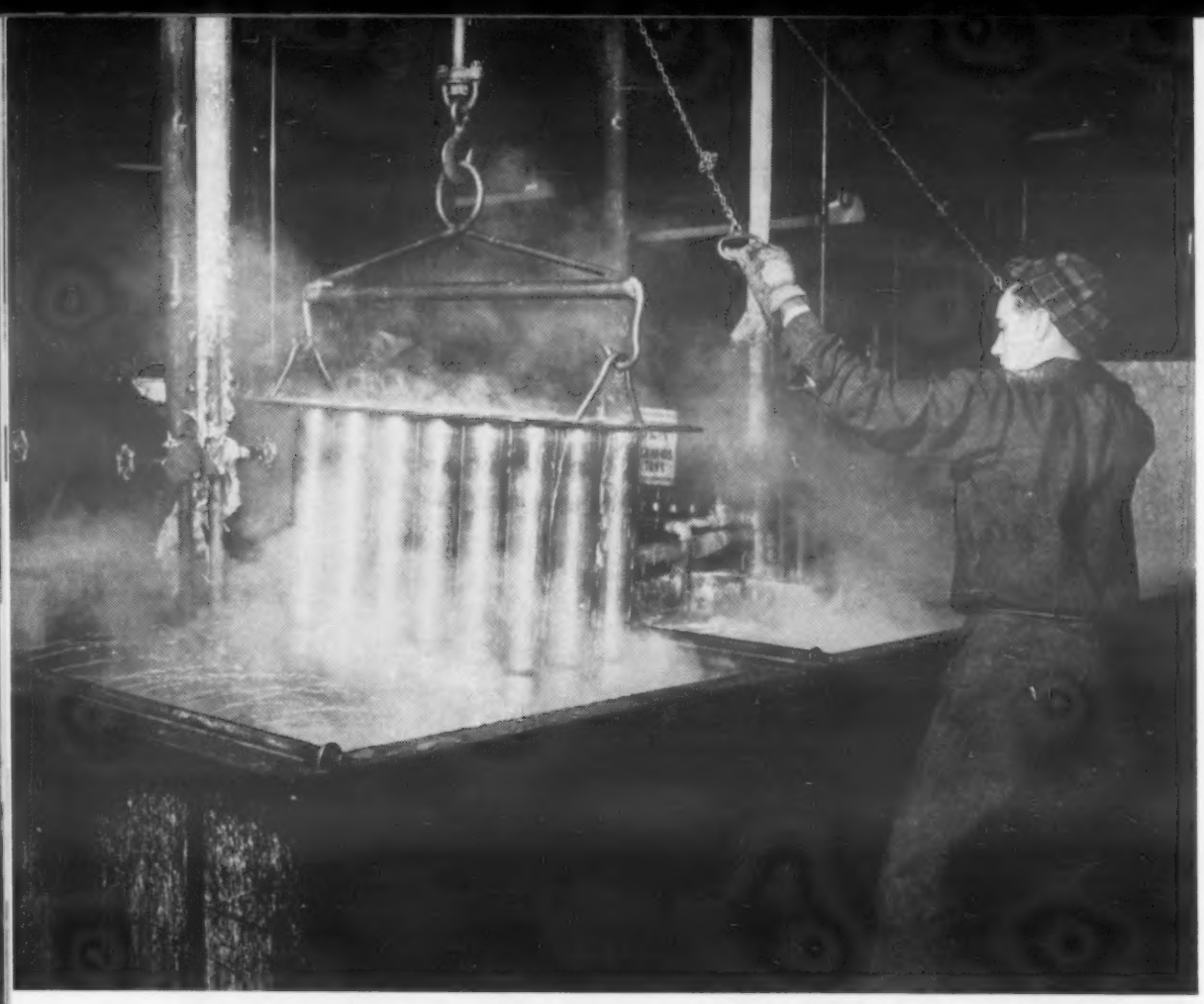
Inert-gas tungsten arc welding of the brasses is difficult because the zinc oxide fumes evolved, interfere with the action of the arc. Machine welding with argon and ac and a copper silicon welding rod appears to produce the best welds by this process.

Inert-gas consumable electrode welding can be used satisfactorily for joining the brasses using either argon or helium or a mixture of the two as a shielding gas. Silicon bronze or aluminum bronze uncoated electrodes are used. Moderate preheating in the range 300 to 500 F assists in minimizing loss of zinc by volatilization.

To make welds comparable to the base metal in composition, gas welding is preferred. Filler rods are generally modifications of Muntz metal but rods can be cut from the base metal. Common practice calls for the use of an oxidizing flame to prevent the volatilization of zinc by developing an oxide film on the surface, a procedure which is very effective in reducing fuming. Suitable fluxes are necessary.

### Surface finishing

*Mechanical and Chemical Cleaning*—Dirt, oils, greases or me-



INTERSTAGE PICKLING and washing are required during the deep drawing of many brass parts. (Copper & Brass Research Assoc.)

tallic particles picked up on the surface during fabrication can be removed by a number of mechanical and chemical cleaning methods. Choice depends on the nature of the soil, the quantity of parts to be cleaned and their size.

Barrel tumbling can be used to remove burrs and tool marks from brass. A mild abrasive such as pumice is preferred if the surface is reasonably bright and free from grease before tumbling. If deburring is not required, a bright finish can be obtained on clean parts by tumbling in a solution of ¼ oz per gal of cream of tartar. Large parts can be cleaned by blasting. Sand or copper shot should be used since the brass is relatively soft and steel shot may become embedded in the surface. Wet blasting with a suspension of abrasive in water can also be used. This procedure has the advantage of permitting greater control of the intensity of the action than dry blast cleaning. Wet blasting can be used not only to deburr but also to remove excess flux from soldering or brazing operations.

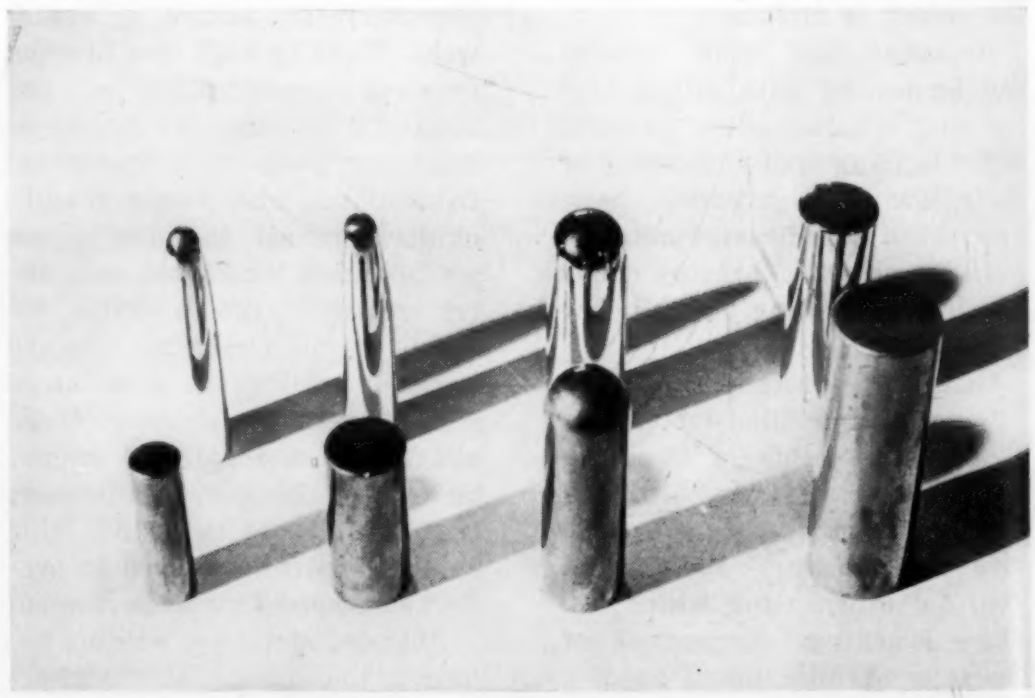
Dirt and oils can be removed from the surface by alkaline cleaning. Inhibited types of cleaners must be used to prevent attack on the surface. Solutions can contain about 4 oz per gal of the cleaner and are operated at about 180 F. Electrolytic cleaning processes employing alkali cleaners are also used for the brasses. Anodic cleaning requires low current density, short immersion time to prevent dezincification and inhibited cleaners.

Solvent cleaners are often used on small parts to remove coolants or cutting oils. The material is immersed in a suitable solvent, usually a low boiling mineral oil fraction and held at a temperature of 120 to 140 F. Only physical cleanliness is obtained by this procedure however.

Vapor degreasing is also used to remove oils and greases. The material is placed in a suitable chamber in which the solvent vapor is condensed. The condensate removes the oils and leaves the surface clean and dry.

*Pickling*—To remove oxides resulting from annealing, the material can be acid pickled. Commonly, this is accomplished by dipping into a solution of dilute sulfuric acid. Concentration can be varied from about 5 to 10% by volume and the temperature from room to about 150 F. The heavier the scale, the more concentrated and hotter the solution.

Pickling in the sulfuric acid solution leaves the surface with a matte appearance. To obtain a brighter and cleaner finish, the part is dipped subsequently in a solution containing about 1½ gal of sulfuric acid and 5 lb of sodium dichromate to 10 gal of water. The part should be com-



RED BRASS, 85% annealed to exceptionally fine grain sizes is used in production of lipstick containers and fountain pen caps where good ductility and ease of buffing for finishing are prime requirements. (Somers Brass Co.)

pletely descaled in the sulfuric acid pickle before being placed in the dichromate solution. Time in the latter should be the minimum required to obtain the desired finish.

*Plating*—For many applications, the brasses are given decorative finishes. Metals such as gold, silver, nickel and chromium can be readily plated on the brasses. Much of the less expensive jewelry, for example, is made by plating silver or gold on a brass base. These coatings average about ½ mil in thickness. For silver-plated table ware, the thickness is increased to about 1 to 2 mils.

DRILLING A PLATE to form a tube sheet. Red Brass, 85% and Muntz metal are used for condensers and heat exchangers. (M. W. Kellogg and Copper & Brass Research Assoc.)

*Mechanical Finishing*—Brasses are frequently polished by mechanical methods. Cloth, felt or sheepskin polishing wheels loaded with alumina or emery can be used for preliminary polishing. This operation can be followed by buffing with a compound giving the desired finish, for example, Tripoil. Rouge yields a high luster for parts to be subsequently lacquered while a satin finish can be obtained by greaseless polishing.

*Coloring*—For decorative purposes, it is frequently desirable to color brass. By immersing the material into solutions of suitable chemicals, various colors can be developed. These include black, blue-black, brown and Old English finish. To preserve the finish, lacquering is necessary.

*Coating*—Suitable lacquers are frequently used to preserve the highly polished finishes on brass but coatings are used also for decorative purposes. Colorful or glossy finishes can be obtained with alkyd enamels or pigmented cellulose lacquers. The harder surface obtained with a fused enamel coating is used for medals and ornaments.

## Applications

As a group these brasses combine good strength, excellent ductility and malleability, high resistance to the atmosphere and to aqueous media and attractive color. Color is one of the characteristics of the brasses which often leads to their selection for applications in which other materials might serve equally well in other respects.

*Gilding, 95%*—The rich bronze color of this alloy leads to its wide use in decorative applications. These include costume jewelry, coins, medals, emblems and plaques. It is an excellent base for finishes and consequently is often gold plated or enameled. However, decoration is not the only field for gilding, 95%. Because it has excellent cold working properties it is used extensively in ordnance items such as bullet jackets, firing pin supports, primers and fuse caps.

*Commercial Bronze, 90%*—The name of this alloy, which is a true brass is derived from its color. It is widely used in hardware applications for such parts as escutcheons, kick plates, marine hardware and fasteners. In ordnance applications it is used for shell rotating bands and primers. Like gilding, it finds many applications in decorative parts such as costume jewelry, compact and lipstick cases, ornamental trim and as a base for vitreous enamel coatings. It is used also for grillwork, weatherstripping, screen cloth and cold headed parts particularly for outdoor applications.

*Red Brass, 85%*—This is the most widely used of the low zinc brasses. Industrial applications include condenser and heat exchanger tubing in the process industry, flexible hose, fasteners, and pickling crates. In the plumbing field, red brass is widely used, for both hot and cold water lines.

In the automotive field, red

## *Typical Applications*

**Gilding, 95 %**
coins, medals, tokens,
bullet jackets, firing pin support shells, fuse caps, primers,
emblems, costume jewelry, plaques,
base for gold plate, base for vitreous enamel

**Commercial Bronze, 90 %**
etching bronze, grillwork, screen cloth, weatherstripping,
compacts, lipstick cases,
escutcheons, kick plates, line clamps, marine hardware, rivets, screws, screw shells,
primer caps, rotating bands,
costume jewelry, ornamental trim, screen wire, vitreous enamel base

**Red Brass, 85 %**
etching parts, trim, weatherstripping,
conduit, screw shells,
eyelets, fasteners, fire extinguishers,
condenser and heat exchanger tubes, flexible hose, pickling crates, plumbing pipe, pump lines, radiator cores,
J-bends, pipe, service lines, traps,
badges, compacts, costume jewelry, dials, etched articles, lipstick containers, nameplates, rouge boxes, tags

**Low Brass, 80 %**
ornamental metal work, medallions, spandrels,
battery caps,
bellows, musical instruments,
clock dials, flexible hose, pump lines, tokens

**Cartridge Brass, 70 %**
ammunition components,
grillwork,
radiator cores and tanks,
flashlight shells, lamp fixtures, screw shells, socket shells,
bead chain, chain, eyelets, fasteners, grommets, finished hardware articles (hinges, kickplates, locks, push plates), stencils,
plumbing accessories, sink strainers,
pins, rivets, screws, springs

**Yellow Brass**
In general, industrial applications similar to those given for Cartridge Brass.

**Muntz Metal**
trimming (architectural),
large nuts and bolts,
brazing rod, condenser plates, condenser, evaporator and heat exchanger tubes, hot forgings, valve stems

brass serves for radiator water lines, although copper is used as spacers and fins because of its greater heat conductivity. Ornamental parts produced by stamping and embossing, followed by either lacquering or nickel-chromium plating, serve as bezels, knobs, mirror frames, medallions, and similar parts. Tubing is used for fuel, oil and brake lines.

Other applications include fire extinguisher cases, builder's hardware, weatherstripping and watch dials. The golden color of this alloy leads to its wide usage in costume jewelry and in similar ornamental applications.

*Low Brass, 80%*—This alloy is used in various formed and drawn parts, flexible metal hose and bellows, battery caps and ornamental metal work. Brass band instruments are usually produced from this material. Metal powder parts are also produced from this composition. A powder metallurgy product is used as a guide for a valve disk in the air release mechanism of a petroleum instrument, for example.

*Cartridge Brass, 70%*—As its name indicates, this brass is widely used for the production of small arms and artillery cartridge cases. This application results from the excellent deep drawing and cold forming properties of the alloy. These properties lead also to its use in such formed parts as reflectors, lamp fixtures, sockets and deep drawn shells of various types. Other uses include snap fasteners, rivets, stamped hardware parts and musical instruments.

*Yellow Brass*—This is probably the best known and at one time was the most widely used of the brasses. However, in recent years it has been largely replaced by cartridge brass and the two alloys are now used interchangeably in many applications. Uses include structural components of electrical apparatus where a moderate strength, corrosion resistant material is required, flashlight cases, sockets, and lamp fixtures.

In the automotive industry, these brasses are used for radiator tanks and cores, gaskets, washers, spacers and various stamped parts. Hardware applications include locks, kick-plates, door-knobs and hinges. They are used in plumbing for fittings and other accessories, often being nickel-chromium plated for appearance. Other uses include pins, rivets, screws, springs, chain and grommets.

*Muntz metal*—This is the only alloy of the group which can be hot worked easily but is not so readily cold worked. Its field of application is therefore somewhat more limited than those of the other brasses mentioned.

Its hot working properties are used to advantage in the production of hot forgings. Automotive gears, hydraulic pistons for brakes, valve stems and similar parts are produced by forging. The alloy is widely used for condenser, heat exchanger and evaporator tubes, tube plates and sheets in the process industries. It is also used in plumbing. Muntz metal brazing rods are used extensively in brazing and, where color is important, can be used to join red brass since the color is similar.

**Acknowledgement**

The assistance received in the preparation of this manual from the personnel and publications of the following organizations is gratefully acknowledged.

American Brass Co.
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Copper & Brass Research Association
Copper Development Association
Eastern Brass & Copper Co., Inc.
Mueller Brass Co.
Revere Copper and Brass Inc.
Scovill Manufacturing Co.
Spincraft, Inc.
Somers Brass Co., Inc.
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Wolverine Tube, Division of Calumet & Hecla, Inc.

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MATERIALS DATA SHEET

## Alkyd Molding Materials

Alkyd molding compounds consist of unsaturated polymerizable alkyd-type resins combined with various fillers. They are available as general purpose, electrical, and high strength materials.

A characteristic of the alkyds is the rapidity and completeness of cure. They can be molded at rates two to three times as fast as other thermosetting compounds and are completely cured as they come from the mold.

Alkyd parts have excellent heat resistance and can be used for limited periods at temperatures in the range 300 to 350 F without undue changes in strength, electrical properties or dimensions.

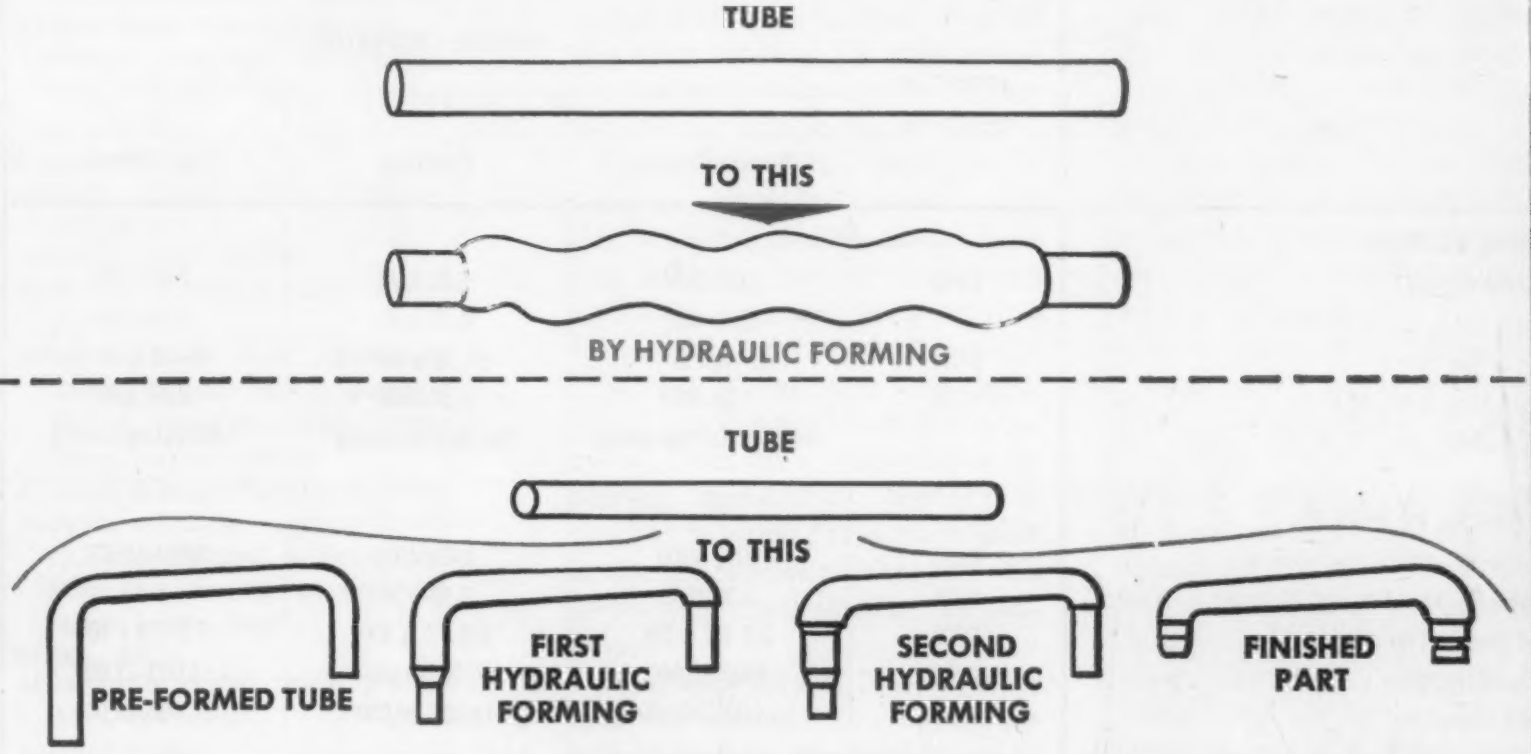
| Type | ASTM Test Conditions | TYPICAL PROPERTIES | | |
|---|---|---|---|---|
| | | General Purpose | Electrical | High Strength |
| PHYSICAL PROPERTIES | | | | |
| Specific Gravity | D792 | 2.22–2.24 | 1.85–2.05 | 2.00–2.08 |
| Therm Cond, Btu/hr/sq ft/ft/°F | — | 0.35–0.60 | 0.35–0.60 | 0.20–0.30 |
| Coef of Exp per °F | D696 | 10–30 x $10^{-6}$ | 10–30 x $10^{-6}$ | 10–30 x $10^{-6}$ |
| Water Absorption, 24 hr % | D570 | 0.08–0.10 | 0.04–0.06 | 0.07–0.10 |
| Flammability | — | Not Self-Extinguishing | Self-Extinguishing | Self-Extinguishing |
| MECHANICAL PROPERTIES | | | | |
| Tensile Str, psi | D651 | 3000–4000 | 3000–4000 | 6000–10,000 |
| Impact Str, Izod Notched (ft-lb per in. of notch) | D256 | 0.30–0.35 | 0.30–0.35 | 8–12 |
| Mod Elast in Flexure, psi | D790 | 2.2–2.7 x $10^6$ | 2.2–2.7 x $10^6$ | 2.2–2.8 x $10^6$ |
| Flexural Str, psi | D790 | 7000–10,000 | 7000–10,000 | 14,000–17,000 |
| Comp Stress, psi | D690 | 16,000–20,000 | 18,000–20,000 | 24,000–28,000 |
| ELECTRICAL PROPERTIES | | | | |
| Vol Resistivity, ohm-cm | D257 | $10^{14}$ | $10^{14}$ | $10^{14}$ |
| Dielectric Str (step by step), volts/mil | D149 | 300–350 | 300–350 | 300–350 |
| Dielectric Constant: | | | | |
| 60 cycles | D150 | 6.0–6.5 | 6.0–6.5 | 5.2–6.0 |
| 1,000,000 cycles | D150 | 4.8–5.0 | 4.2–4.5 | 4.0–4.5 |
| Power Factor: | | | | |
| 60 cycles | D150 | 0.050–0.060 | 0.035–0.040 | 0.02–0.03 |
| 1,000,000 cycles | D150 | 0.016–0.018 | 0.014–0.015 | 0.017–0.022 |
| FABRICATING PROPERTIES | | | | |
| Compression Ratio (Bulk Factor) | D954 | 1.95–2.15 | 1.85–2.05 | 9–11 |
| Compression Molding Pressure, psi | — | 1000–1500 | 1000–1500 | 1500–2000 |
| Compression Molding Temp, F | — | 270–330 | 270–330 | 270–330 |
| MAXIMUM RECOMMENDED SERVICE TEMP, F LIMITED PERIODS | — | 350 | 300 | 350 |
| CORROSION RESISTANCE | D543 | Resistant to weak acids; attacked by alkalies; practically unattacked by organic liquids such as alcohols, hydrocarbons, fatty acids | | |
| USES | — | Ignition parts, fuse blocks, switch and circuit breaker covers and bases, molded resistors and capacitors, television tuner segments | | |

*Prepared with the assistance of the Barrett Div., Allied Chemical & Dye Corp*

For more information, Circle No. 475

# IF YOU PRODUCE PARTS FROM STEEL TUBING...

## *it may pay you to investigate new forming methods*




Often a single change made in your production procedures can result in a better product with savings in fabricating time and cost. And even if your current production methods are "good enough", you can't afford to overlook any improvement which might be adapted to your operation. For example, hydraulic forming is a unique, simple forming method having advantages—where applicable—which include fewer operations to produce the finished part, reduced tool costs and lower maintenance costs.

But whether you form your product hydraulically or by other methods, the original tubing you choose must be *right* . . . must have the precise combination of formability and strength required for your product. Only with the *right* tubing can you make that product to quality standards, at the lowest possible cost to yourself. And whatever your manufacturing requirements may be, B&W Mechanical Tubing can meet them. It is available in the fullest range of analyses, sizes, finishes and properties, and *one* combination of these is tubing tailor-made to your requirements.

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B&W SEAMLESS and WELDED TUBES

TA 4055(M)

For more information, turn to Reader Service Card, Circle No. 327

## Characteristics of Magnesium Alloys

| ALLOY NO. | | | NOMINAL COMPOSITION (Mg-Remainder) | | | Heat Treatment | Spec Gr (75 F) | Density, Lb/Cu In. | M. P. F | Therm Cond, Btu/Hr/Sq Ft/Ft/°F 212–570 F | Elect Resist, Microhm-Cm 68 F |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ASTM | DOW | AMC | Al | Zn | Mn | | | | | | |
| SHEET | | | | | | | | | | | |
| AZ31B | FS1-0 | C52S-0 | 3.0 | 1.0 | — | 0 | 1.77 | 0.064 | 1160 | 56 | 10.0 |
| | FS1-H24 | C52S-H24 | 3.0 | 1.0 | — | H24 | 1.77 | 0.064 | 1160 | 56 | 10.0 |
| | FS1-F | C52S-F | 3.0 | 1.0 | — | F | 1.77 | 0.064 | 1160 | 56 | 10.0 |
| M1A | M-0 | 3S-0 | — | — | 1.2 | 0 | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| | M-H24 | 3S-H24 | — | — | 1.2 | H24 | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| | M-F | 3S-F | — | — | 1.2 | F | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| BARS | | | | | | | | | | | |
| AZ31B | FS1 | C52S | 3.0 | 1.0 | — | — | 1.77 | 0.064 | 1160 | 56 | 10.0 |
| AZ61A | J1 | C57S | 6.5 | 1.0 | — | — | 1.80 | 0.065 | 1145 | 46 | 12.5 |
| AZ80A | O1 | C58S | 8.5 | 0.5 | — | — | 1.80 | 0.065 | 1130 | 54 | 14.5 |
| M1A | M | 3S | — | — | 1.2 | — | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| SHAPES | | | | | | | | | | | |
| AZ31B | FS1 | C52S | 3.0 | 1.0 | — | — | 1.77 | 0.064 | 1160 | 56 | 10.0 |
| AZ61A | J1 | C57S | 6.5 | 1.0 | — | — | 1.80 | 0.065 | 1145 | 46 | 12.5 |
| AZ80A | O1 | C58S | 8.5 | 0.5 | — | — | 1.80 | 0.065 | 1130 | 54 | 14.5 |
| AZ80A | O1-T6 | C58S | 8.5 | 0.5 | — | T6 | 1.80 | 0.065 | 1130 | 54 | 14.5 |
| M1A | M | 3S | — | — | 1.2 | — | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| TUBING | | | | | | | | | | | |
| AZ31B | FS1 | C52S | 3.0 | 1.0 | — | — | 1.77 | 0.064 | 1160 | 56 | 10.0 |
| AZ61A | J1 | C57S | 6.5 | 1.0 | — | — | 1.80 | 0.065 | 1145 | 46 | 12.5 |
| M1A | M | 3S | — | — | 1.2 | — | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| CASTINGS | | | | | | | | | | | |
| AM100A | G | 240 | 10.0 | — | 0.1 | F | 1.81 | 0.066 | 1100 | — | — |
| | | | 10.0 | — | 0.1 | T4 | 1.81 | 0.066 | 1100 | — | — |
| | | | 10.0 | — | 0.1 | T6 | 1.81 | 0.066 | 1100 | — | — |
| AZ63A | H | 265 | 6.0 | 3.0 | — | F | 1.83 | 0.067 | 1135 | 54 | 11.5 |
| | | | 6.0 | 3.0 | — | T2 | 1.83 | 0.067 | 1135 | 54 | 11.5 |
| | | | 6.0 | 3.0 | — | T4 | 1.83 | 0.067 | 1135 | 54 | 11.5 |
| | | | 6.0 | 3.0 | — | T6 | 1.83 | 0.067 | 1135 | 54 | 11.5 |
| AZ92A | C | 260 | 9.0 | 2.0 | — | F | 1.82 | 0.066 | 1110 | 39 | 16.0 |
| | | | 9.0 | 2.0 | — | T2 | 1.82 | 0.066 | 1110 | 39 | 16.0 |
| | | | 9.0 | 2.0 | — | T4 | 1.82 | 0.066 | 1110 | 39 | 16.0 |
| | | | 9.0 | 2.0 | — | T6 | 1.82 | 0.066 | 1110 | 39 | 16.0 |
| M1B | M | 403 | — | — | 1.2 | F | 1.76 | 0.064 | 1200 | 73 | 5.0 |
| | R | 263 | 9.0 | 0.6 | — | — | 1.81 | 0.066 | 1120 | 41 | 17.0 |

*(Continued on page 133)*

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## Characteristics of Magnesium Alloys (continued)

| ALLOY NO. | | | Heat Treatment | TENSION | | | COMP 1000 psi | | BEARING 1000 psi | | Shear Str, 1000 psi | Fatigue Str, (1) 1000 psi | HARDNESS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASTM | DOW | AMC | | Ult Str, 1000 psi | Yld Str, 1000 psi | % Elong in 2 in. | Ult Str | Yld Str | Ult Str | Yld Str | | | Brinell | Rockwell |
| SHEET | | | | | | | | | | | | | | |
| AZ31B | FS1-O | C52S-O | O | 37 | 22 | 21 | — | 16 | 75 | 36 | 21 | 12 | 56 | E67 |
| | FS1-H24 | C52S-H24 | H24 | 42 | 32 | 16 | — | 27 | 78 | 53 | 23 | 14 | 73 | E83 |
| | FS1-F | C52S-F | F | 37 | 22 | 21 | — | — | 75 | 36 | 21 | — | — | — |
| M1A | M-O | 3S-O | O | 33 | 18 | 16 | — | 12 | 60 | 28 | 18 | 9 | 48 | E55 |
| | M-H24 | 3S-H24 | H24 | 37 | 28 | 7 | — | 20 | — | — | — | 10 | 56 | E67 |
| | M-F | 3S-F | F | 33 | — | — | — | — | — | — | — | — | — | — |
| BARS | | | | | | | | | | | | | | |
| AZ31B | FS1 | C52S | — | 37 | 26 | 12 | 60 | 15 | 65 | 35 | 19 | 14 | 45 | E57 |
| AZ61A | J1 | C57S | — | 45 | 32 | 14 | — | 20 | 76 | 44 | 20 | 18 | 58 | E70 |
| AZ80A | O1 | C58S | — | 48 | 32 | 12 | — | 22 | 76 | 50 | 22 | 18 | 60 | E78 |
| M1A | M | 3S | — | 34 | 26 | 9 | — | 12 | 56 | 28 | 18 | 9 | 44 | E45 |
| SHAPES | | | | | | | | | | | | | | |
| AZ31B | FS1 | C52S | — | 37 | 26 | 12 | — | 15 | 65 | 35 | 19 | 14 | 45 | E57 |
| AZ61A | J1 | C57S | — | 44 | 28 | 14 | — | 19 | — | — | — | — | 64 | E76 |
| AZ80A | O1 | C58S | — | 48 | 32 | 12 | — | 22 | 76 | 50 | 22 | 18 | 60 | E77 |
| AZ80A | O1-T6 | C58S | T6 | 52 | 36 | 5 | — | 33 | 90 | 62 | 24 | 19 | 82 | E88 |
| M1A | M | 3S | — | 34 | 26 | 9 | — | 12 | 56 | 28 | 18 | 9 | 44 | E45 |
| TUBING | | | | | | | | | | | | | | |
| AZ31B | FS1 | C52S | — | 35 | 23 | 12 | — | 15 | — | — | — | — | 46 | E51 |
| AZ61A | J1 | C57S | — | 41 | 20 | 13 | — | 15 | — | — | — | — | 50 | E60 |
| M1A | M | 3S | — | 32 | 20 | 6 | — | 10 | — | — | — | — | 42 | E41 |
| CASTINGS | | | | | | | | | | | | | | |
| AM100A | G | 240 | F | 22 | 13 | 2 | 48 | 13 | — | — | 17 | 10 | 54 | E65 |
| | | | T4 | 33 | 12 | 8 | 50 | 12 | — | — | 19 | 12 | 52 | E62 |
| | | | T6 | 34 | 19 | 2 | 54 | 19 | — | — | 21 | 10 | 69 | E80 |
| AZ63A | H | 265 | F | 29 | 14 | 6 | 45 | 14 | 65 | 42 | 18 | 11 | 50 | E59 |
| | | | T2 | 29 | 14 | 5 | — | — | 65 | 42 | 19 | 11 | — | — |
| | | | T4 | 40 | 14 | 12 | 46 | 14 | 70 | 42 | 19 | — | 55 | E66 |
| | | | T6 | 40 | 19 | 5 | 50 | 19 | 80 | 56 | 21 | 14 | 73 | E83 |
| AZ92A | C | 260 | F | 24 | 14 | 2 | 55 | 14 | 60 | 48 | 19 | 11 | 65 | E77 |
| | | | T2 | 24 | 14 | 2 | — | — | 60 | 48 | 19 | 11 | 65 | E77 |
| | | | T4 | 40 | 14 | 10 | 60 | 14 | 75 | 48 | 20 | 14 | 63 | E75 |
| | | | T6 | 40 | 23 | 2 | 70 | 23 | 85 | 65 | 21 | 13 | 84 | E90 |
| M1B | M | 403 | F | 14 | 4.5 | 5 | 27 | 4.5 | — | — | 11 | — | 33 | E 3 |
| | R | 263 | — | 33 | 22 | 3 | 58 | 22 | — | — | 20 | 14 | 60 | E72 |

*NOTES:*
*(1) Based on 500 million cycles of completely reversed stress.*
*Mod of Elast 6,500,000 psi.*
*Mod of Rigidity 2,400,000 psi.*
*Poisson's Ratio 0.35.*
*Coef of Therm Exp 14.5 x $10^{-6}$ per F (68 to 212 F).*

*Courtesy of "The Magazine of Magnesium" published by Brooks & Perkins, Inc.*

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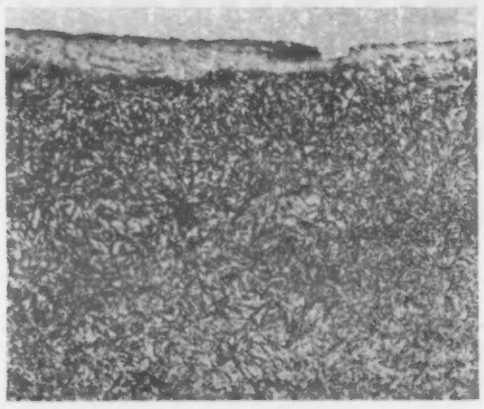
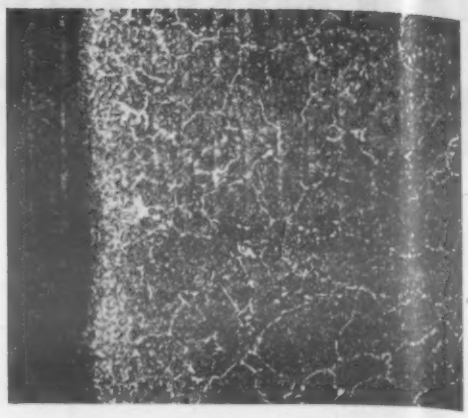
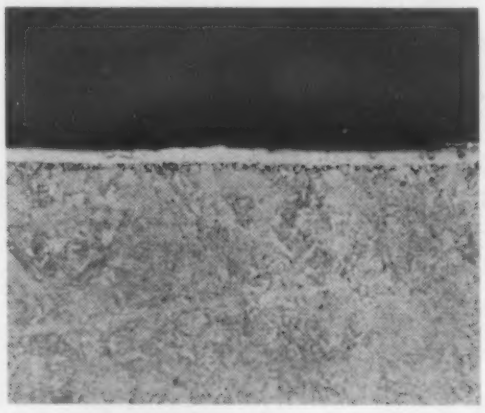


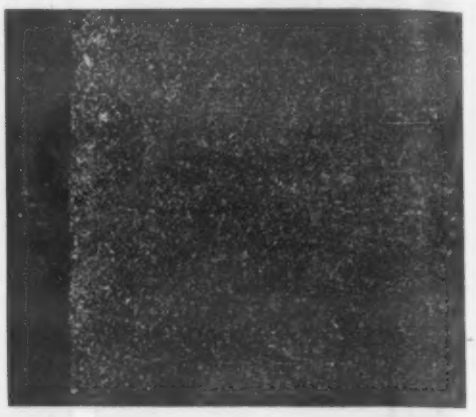
Excessive retained austenite in a carburized case. White layer on surface is copper flash. (Magnification 500X).



Excessive carbides in a carburized case. (Magnification 500X).



Subsurface scale in a carburized case. Scale is black constituent below copper flash. (Magnification 500X).



Properly heat treated eutectic structure in a carburized case. (Magnification 500X).

# How to Obtain High Quality Carburized Cases

*These practical notes show how uniform results can be obtained by relatively simple procedures.*


**by H. E. Mansfield,**
*Curtiss-Wright Corp.*


■ THE SPECIFIC REQUIREMENTS of a carburized case depend on the application. The carbon content required to yield sufficient hardness to withstand the maximum wear under the operating conditions is the factor governing the lower limit of carbon concentration. This requirement is usually specified in terms of surface hardness. In addition, the upper and lower limits of carbon concentration provide for the crys-

tal structure best able to withstand the effect of critical loading. Optimum properties are obtained with a slightly hypereutectoid structure. A carbon concentration in the case of more than 1% is considered less desirable because of the resultant carbides and retained austenite. The brittle carbides and the possible retained austenite under some conditions are potential cause of pits and grinding checks which nucleate larger cracks and subsequent failures.

The proper equipment to case carburized parts with the consistency necessary for good engineering control is subject to much debate. However, a gas atmosphere meets all requirements most frequently.

Gas carburizing furnaces are generally heated by electricity, although gas fired equipment is also used. The carburizing medium varies from natural gas, through many prepared gases to liquids which are gasified upon admission to the heating chamber. Carrier gases vary greatly. They include endo-gas, exo-gas, dissociated ammonia and others. Most combinations of the gases mentioned when properly controlled, can produce consistent aircraft quality work factors. Essentially there are two prime considerations, temperature uniformity and atmosphere control.

### Temperature Uniformity

The degree of temperature uniformity determines whether or not consistent case depth will be attained from one part to another. Fortunately, uniformity can be attained by relatively simple procedures. First, of course, is having good equipment including temperature and input controllers, thermocouples and for gas fired furnaces, proper regulators. Second is employing the equipment properly. Proper use of controllers is obvious, but improper thermocouple location often leads to misleading temperature indications. The location is best determined by using a multipoint recorder connected to thermocouples, embedded in metal and located at the center and extremities of the work area and in the control couple well. The control couple is then placed in the location that will maintain the work area at the carburizing temperature $\pm$ 10 F.

Needless to say, a furnace showing temperature uniformity when empty, can become nonuniform if it is improperly loaded. Poor distribution of the work load can upset the temperature balance sufficiently to cause variations in case depth from one part to another. Parts must be arranged to occupy as much of the working area as possible without interfering with the flow of the carburizing gas.

### Atmospheres

Furnace atmospheres must also be controlled at the proper carbon potential and be uniform throughout the working zone. The carbon potential is influenced by the furnace size, inherent properties of the gases used, rate of flow and circulation of the gas and the total area of the parts to be carburized. Satisfactory results have been obtained in a 25 x 36-in. pit furnace, employing a fluid flow of 8 cc/3 min and a 2000 to 8000-sq in. work load for example. However proper conditions change with each combination of variables.

Obtaining atmosphere uniformity throughout the working chamber is a problem. The factor most often responsible for variations is lack of "tightness". Even when a furnace is free from leaks at the beginning of a cycle, one cannot be positive that leaking will not develop during the run. Preventative maintenance helps and a regular check on the pressure is the guide to the "tightness" of a furnace. Maintaining a positive pressure reduces the tendency for diffusion of air into the furnaces. The minimum pressure needed will, of course, vary with the furnace size.

A leaking furnace, can cause defects ranging from an actual decarburized layer on the surface of the part being carburized to an intergranular oxide attack known as subsurface scale.

*(Continued on page 136)*

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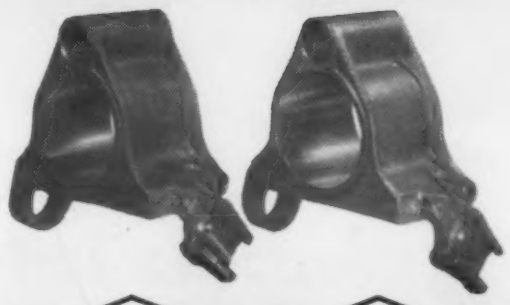

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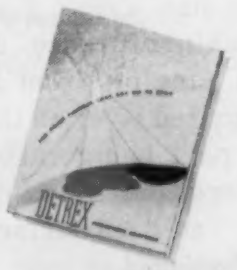



DETREX CORPORATION
DEPT. PB-302, BOX 501, DETROIT 32, MICH.


## HIGH QUALITY CARBURIZED CASES

*(Continued from page 135)*

Either condition is potentially dangerous on the surface of a part designed to exacting standards.

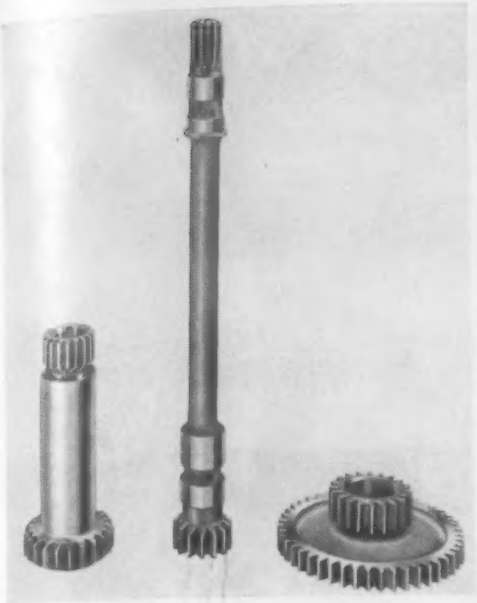
### Cooling and Hardening

The cooling cycle after carburizing depends on the composition of the steel and the subsequent operations. For low alloy chromium nickel series it has been found best to cool to room temperature prior to reheating for hardening. This treatment materially decreases the amount of retained austenite. Cooling must be done sufficiently rapid to prevent the formation of a carbide network.

The hardening cycle is as important as the carburizing cycle because a good carburizing job can be readily ruined by improper hardening. Theoretically, placing the carburized parts in a heated chamber having an atmosphere in which the carbon potential is equivalent to the carbon concentration in the carburized case is a good hardening technique. Practically, this treatment has obvious commercial limitations. Hence, a procedure involving copper flashing before hardening and employing an atmosphere sufficient to protect the flash from oxidizing has been adopted. This procedure followed by quenching under a protective atmosphere protects the work completely. Where hardening cannot be done under a protective atmosphere, a 0.001-in. copper plate gives adequate protection. However, good adherence of the copper is necessary because blisters are as detrimental as no protection.

All of these factors are important in aircraft quality carburizing. To ignore them is to compromise on quality. Retained austenite and subsurface scale and, in some instances, structures containing excessive carbides cause a decrease in the life of the carburized part. Each of these structures can be traced to

For more information, Circle No. 361



Production of aircraft quality gears requires careful control.

a relaxation of the controls mentioned. Adherence to proper technique produces a satisfactory predominantly eutectoid structure.

Processing which follows carburizing affects the degree to which controls must be enforced. For example, on gears to be ground after case hardening, the case could conceivably be below quality specifications to the depth that would be removed. This depth can be as much as 0.007 to 0.020 in. However, eccentric grinding can, and often does reduce the allowable imperfections on the surface. On the other hand shaved gears, having only a zirconite blasting operation after heat treatment, which removes about 0.0001 in. of materials from the surface can tolerate little or no surface imperfections. Distortion is a most important consideration in the case carburizing of shaved gears. This is, of course, emphasized by the tolerances permitted and the subsequent negligible stock removal. Control of distortion is dependent on the contour and mass of each individual piece. Quenching fixtures, dies and presses and quenching direction and speed must be regulated to suit the specific applications. Straightening after heat treatment is not accepted since increased stress concentrations, for many parts, would result in stresses exceeding specification limits.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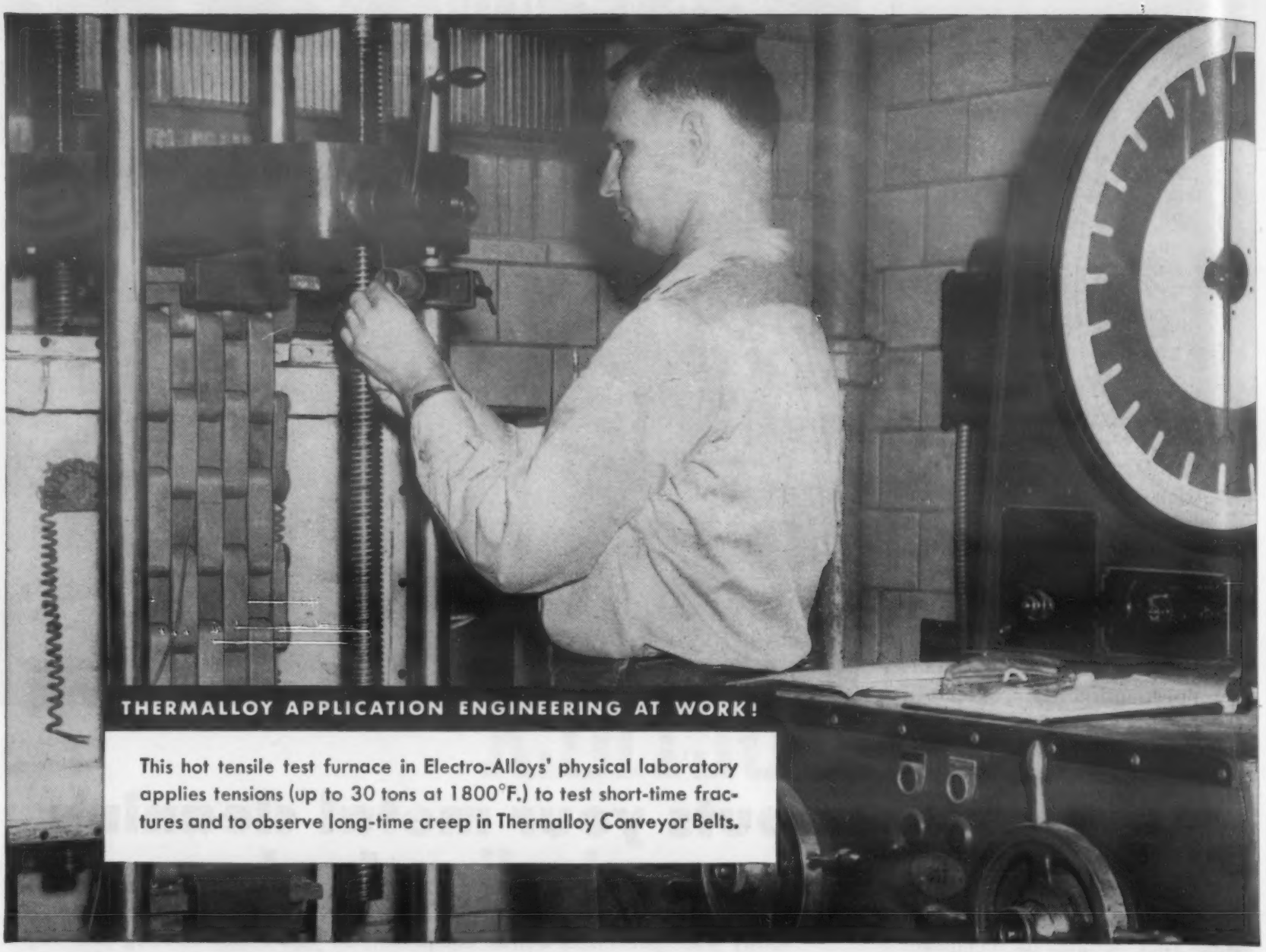
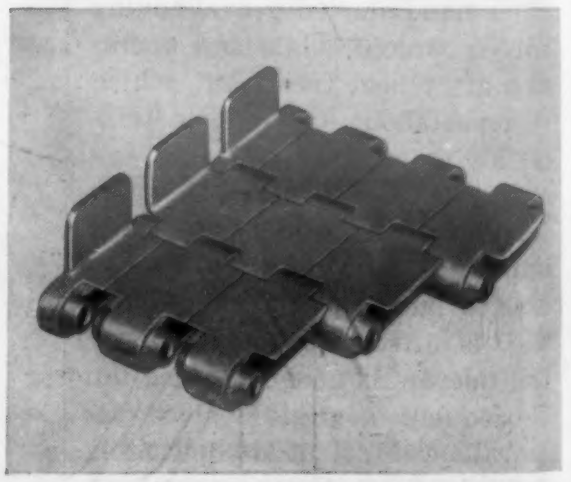

THERMALLOY APPLICATION ENGINEERING AT WORK!
This hot tensile test furnace in Electro-Alloys' physical laboratory applies tensions (up to 30 tons at 1800°F.) to test short-time fractures and to observe long-time creep in Thermalloy Conveyor Belts.

# A miniature furnace to test theories!

Service life of a heat-treating furnace conveyor belt may be affected by so many variables, i.e. uneven loading, misalignment, temperature differentials, etc., that proper design, highest quality and the right material are of utmost importance.

At Electro-Alloys, a staff of engineers and metallurgists are constantly studying these factors in the physical testing laboratory shown above. A hot tensile test furnace is continually in use subjecting Thermalloy* conveyor belts to various combinations of loading and temperature. In this way, design theories developed by our engineers are tested and highest possible quality standards are maintained to insure production of furnace conveyor belts that will be the ultimate in trouble-free operation.

Electro-Alloys also applies engineering and metallurgical know-how in the production of heat-resistant Thermalloy castings for other furnace parts such as sprockets, idlers, skid rails or rollers, crossbeams, wall boxes and radiant tube assemblies. For complete information, call our nearest representative or write for Thermalloy Conveyor Belt Bulletin T-241, Electro-Alloys Division, 6001 Taylor St., Elyria, Ohio.



To meet extra-severe operating conditions, a Thermalloy Heavy-Duty Conveyor Belt was developed. This partially assembled belt shows the short integral cast pins that eliminate "crank-shafting."

AMERICAN Brake Shoe COMPANY

**ELECTRO-ALLOYS DIVISION**

**Elyria, Ohio**

*Reg. U. S. Pat. Off.

For more information, turn to Reader Service Card, Circle No. 450

# New Materials, Parts and Finishes | and related equipment

## Epoxy-Glass Laminate Provides Uniform Properties, Simplified Forming

An uncured epoxy-impregnated glass laminate has been developed which provides consistent strength properties and may be formed by matched die, bag molding or vacuum forming methods. Marketed by *Minnesota Mining and Mfg. Co.*, 900 Fauquier St., St. Paul 6, Minn., the material, called Scotchply, consists of one or more uncured moldable sheets of epoxy resin, each of which is reinforced with lineally aligned continuous glass filaments. The filaments as well as the curing agent in each sheet are said to be uniformly dispersed, and the composition is 60% glass, 40% resin by weight. The only preparatory step prior to use is the removal of a protective paper liner from the surface of the material.

**Three forms available**

Scotchply is currently available in three forms:

1. If high strength is desired in only one direction, all filaments may be oriented in that direction in the plies of the laminate.

2. If a strength relationship is desired in two principal directions, the filaments in the plies of the laminate can be oriented in those directions.

3. If equal strength is desired in all directions, plies are laminated so that filaments run at 120 deg angles.

According to the company, the controlled production process insures uniformity of properties from sheet to sheet, and the epoxy resins provide a high degree of adhesion to the glass and optimum physical properties. The material can be cured by the addition of heat and pressure. Cure time is 35 min at 330 F under a molding pressure of 25 psi. Cure time can be shortened by increasing temperatures to 350 to 450 F.

The material is available in special forms such as ready-to-mold colors, wood grains, metal foils or other finishes built into the top layer of the uncured laminate. In its cured form the

THE UNCURED sheet material can be formed by many methods.

**TYPICAL PROPERTIES OF SCOTCHPLY (ISOTROPIC SHEET STOCK)[1]**

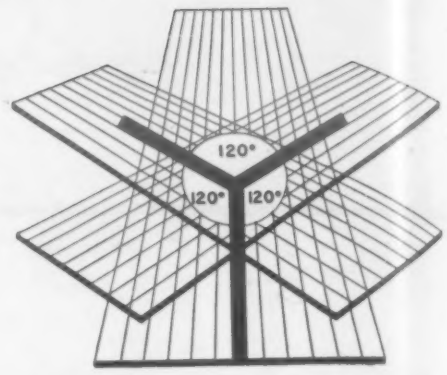
| PHYSICAL PROPERTIES | TEST METHOD | VALUES |
|---|---|---|
| Ten Str, psi | ASTM D638-52 | 41,000 |
| Mod of Elast in Tension, psi | — | $3.00 \times 10^6$ |
| Flex Str, psi | ASTM D790-49T | 64,500 |
| Mod of Elast in Tension, psi | — | $3.20 \times 10^6$ |
| Repeated Flex Fatigue Str | Like ASTM D671-51T | — |
| 28,000 psi Stress | — | 1000 (cycles to failure) |
| 13,000 psi Stress | — | 5,000,000 (cycles without failure) |
| Comp Str, psi | Fed. Spec. L-P-406b Method 1021.1 | 42,000 |
| Izod Imp str, ft-lb/in. notch | ASTM D790-49T notched | 45 |
| Rockwell Hardness (M) scale | ASTM D785-51 | 105 |
| Water Absorption, 24 hr at 70 F, % | ASTM D570-42 | 0.002 |
| Heat Distortion at 264 psi, F | ASTM D648-45 | 350 |
| Sp Gr | — | 1.80 |

| ELECTRICAL PROPERTIES[2] | 60 CYCLES | 1 KC | 100 KC |
|---|---|---|---|
| Dielectric Constant | 5.25 | 5.20 | 5.10 |
| Dissipation Factor | 0.0043 | 0.0049 | 0.011 |
| Vol Resist (Ohms) | $1 \times 10^{16}$ | — | — |
| Dielectric Str, v/m | — | 700 | — |

[1] *Glass (wt), 60%.*
*Resin (wt), 40%.*
*Molding Pressure, 25 psi.*
*Cure Time, at 330 F, 35 min.*
[2] *Tests conducted at 23 C, 50% R.H. and at 90% R.H.*

material is said to be shatterproof, rotproof, mildewproof, and waterproof. It can be sawed, sheared, punched, drilled, sanded, painted, cemented and polished. The uncured material is said to have a shelf life of about 30 days at normal room temperature, though this can be increased to 4 mo when stored at 40 F. Scotchply is now being produced in pilot plant quantities, and is available in sheet or roll form depending on thickness.

Applications for the material are expected to be found in aircraft structures, automotive parts and assemblies, electrical printed circuits, shipping containers, safety equipment, structural units in chemical plants, railroad cars, storage tanks, machine housings as well as other typical applications for reinforced plastics.




ORIENTING THE FIBERS in a three-ply laminate in this manner provides isotropic strength characteristics.

## New Die Steel Has High Wear Resistance

A new high carbon-high vanadium die steel has been developed specifically for deep drawing and forming stainless steel by *Allegheny Ludlum Steel Corp.*, 2020 Oliver Bldg., Pittsburgh 22. Called Ottawa 60, the alloy is produced in bars and forgings, and tools made of the material are said to form stainless steels without galling or pickup and to provide optimum wear resistance. The alloy is composed of vanadium carbides dispersed uniformly through a hard matrix when heat treated. Typical analysis is carbon, 3.25; chromium, 1.00; molybdenum, 1.00; vanadium 12.00%.

### Hardness and impact strength

Tests conducted by the producer indicate hardness values between Rc 62 and 66.5 on samples hardened at temperatures ranging from 1600 to 1900 F. The optimum hardening range for both open fire and pack hardening was found to be 1750 to 1800 F where hardness values of 65 to 66.5 Rc were obtained. After drawing for 2 hr at 1000 F, samples hardened at temperatures between 1600 to 1900 F showed hardness values ranging from 54 to 58 Rc.

To determine impact strengths, unnotched Izod impact samples 3 in. long by 0.394 in. square were prepared from ½-in. square annealed bar stock by grinding to 0.404 in. square, preheating at 1300 F, transferring to a high heat electric furnace at 1750 F and cooling in air. After tempering at various test temperatures for 2 hr, they were wet ground to 0.394 in. square and tested in a 120 ft-lb Izod machine. At tempering temperatures ranging from 300 to 900 F impact values of 11 to 20 ft-lb were obtained at measured hardness values of 65.5 to 57 Rc.

### Recommended conditions for forming

For forging it is desirable to preheat to 1400 to 1500 F. Since the material is highly alloyed, heat penetration is slow. When heated through at this temperature bring up to 2000 to 2100 F. The forging range is rather narrow and reheating may be necessary if temperatures fall below 1700 F. After forging, parts should cool slowly out of contact with air currents or dampness. Annealing should be carried out in all cases.

Pack annealing in a neutral compound is recommended. Bring slowly to 1500 F and allow charge to heat through, then cool slowly in furnace. In the fully annealed condition hardness will range from 27 to 30 Rc. In general, pack hardening or salt bath hardening is recommended for Ottawa 60. The packing compound should be completely spent or neutral as the steel readily picks up carbon. Heat slowly to 1750 to 1800 F and hold for 1 to 3 hr, depending on the size of the part. Usually Ottawa 60 should be held slightly longer at temperature than the high carbon-high chromium grades.

Tempering should be started as quickly as possible after the material has cooled after hardening. The usual tempering range is 300 to 700 F, depending on the hardness desired. The material will resist softening better than the high carbon-high chromium steels.

Due to the many hard vanadium carbides present, the new steel will not machine as well as high carbon-high chromium tool steels. However, it can be machined and cut by conventional methods other than hack or band sawing. Due to the high wear resistance in the hardened condition grinding must be carried out carefully using aluminum oxide or diamond wheels. It may be polished satisfactorily with diamond dust. Use of techniques developed for grinding sintered tungsten carbides will ensure proper results.

## Glass-Filled Silicone Molding Compound for High Temperatures

A high impact, glass-filled silicone molding compound has been developed to produce electrical and electronic parts for high service temperatures. Properly molded, the material is said to withstand continuous exposure at 450 F and intermittent exposure to 650 F. Maximum physical properties for the material are obtained by compression molding, according to the producers, *Dow Corning Corp.* Midland, Mich. Typical properties of the material, molded at 340 F for 10 min, include a tensile strength of 5000 to 7000 psi, a compressive strength of 10,000 to 12,000 psi, and an impact strength ranging from 15 to 22 ft-lb per in. of notch.

### Characteristics of material

Designated Dow Corning 301, the uncured molding compound has a heat distortion point of about 300 F; therefore where parts must carry loads at higher service temperatures, a 1-hr cure at 400 F is recommended. Such a cure is said to provide a heat distortion point of 900 F. If the part is not under load, heat aging in service may be employed to raise the heat distortion point.

Physical properties of moldings will vary with mold design, preforming, and shape and size of the part. Fiber length in the standard 301 compound is approximately 7/8 in. Shorter lengths, available on request, will provide better surface appearance but lower strengths.

### Molding methods

Since the material has a high bulk factor (6 to 7) some pre-

INTRICATE MOLDINGS and extrusions are possible with the material.

**TYPICAL PROPERTIES**
**DOW CORNING 301 COMPRESSION MOLDINGS**

| PHYSICAL PROPERTIES | ASTM TEST METHOD | AS MOLDED[a] | REGULAR AFTERBAKE[b] |
|---|---|---|---|
| Sp Gr, at 75 F | — | 1.65 | 1.65 |
| Density, lb/cu ft | — | 105.8 | 105.8 |
| Flex Str, psi | D 790-49T | — | — |
| at 75 F | — | 14,000 | 12,000 |
| at 400 F | — | 5000 | 6000 |
| Flex Mod | D 790-49T | — | — |
| at 75 F | — | $1.8 \times 10^6$ | $1.6 \times 10^6$ |
| at 400 F | — | $0.9 \times 10^6$ | $1.1 \times 10^6$ |
| Ten Str, psi | D 651-48 | — | — |
| at 75 F | — | 4400 | 4500 |
| at 400 F | — | 1300 | 2500 |
| Comp Str, psi | D 695-52T | — | — |
| at 75 F | — | 10,000 | 9500 |
| at 400 F | — | 2800 | 4000 |
| Izod Imp Str, | D 256-47T | — | — |
| ft lb/in. notch at 75 F | — | 15 | 15 |
| at 400 F | — | 11 | 11 |
| Water Absorption, % | D 570-42 | 0.10 | 0.13 |
| Heat Resistance, F | | | |
| Continuous | — | 450 | 450 |
| Short Time | — | 650 | 650 |
| Heat Distortion Temp, F | — | 300[c] | >900 |
| Lin Coef of Exp | D 696-44 | — | $8 \times 10^{-6}$ |
| Flammability | D 635-44 | Self-extinguishing | |
| Machinability | — | High speed tools | |
| **ELECTRICAL PROPERTIES** | | | |
| Dielectric Str, v/m (short time, samples 1/8 in. thick) | D 149-44 | — | — |
| in air, at 75 F | — | 100–200 | 100–175 |
| at 400 F | — | 100–200 | 100–175 |
| Dielectric Constant at 75 F | D 150-47T | — | — |
| dry, at $10^3$ cycles | — | 3.6 | 3.2 |
| at $10^6$ cycles | — | 3.5 | 3.2 |
| Dissipation Factor | D 150-47T | — | — |
| dry, at $10^3$ cycles | — | 0.007 | 0.005 |
| at $10^6$ cycles | — | 0.004 | 0.005 |
| Arc Resistance, sec | D 495-48T | 220 | 220 |

[a] *Molded from loose compound 10 min at 340 F and 4000 psi, pulled hot.*
[b] *Molded samples cured for 16 hr at 200°F and then 2 hr each at 250, 300, 350, and 400 F. Heat aging at 400 F for 1 hr will raise the heat distortion temperature to greater than 900 F*

forming is usually needed. Preform dies should be approximately the same shape as the mold cavity and should be designed to assure proper resin flow. Avoid multiple preforms if possible, as tests indicate difficulty in obtaining proper welding at the interface.

When forming by the compression molding method, molding temperatures and pressure, and cure time vary with the size of the piece and type of mold. A temperature of 350 F is recommended at pressures of 1000 to 4000 psi. Cure times will vary from 5 min for small, simple forms to 30 min for larger, more complex shapes. It is unnecessary to cool the mold below molding temperatures before removing the part.

The 301 compound can also be transfer molded with relative ease after proper preheating. Large gates and runners should be provided to reduce transfer pressure and to prevent damage to the glass fibers. If inserts are used, the gating should be designed to prevent weld lines.

**SUGGESTED MOLDING CONDITIONS**

| | |
|---|---|
| Preforming Pressure, psi | 1000 |
| Preheat, min at 230 F: | |
| Loose Compound, oven | 2 |
| Preformed Compound, electronic | 1–2 |
| Molding Pressure, psi | |
| Compression | 1000–4000 |
| Transfer | 5000–10,000 |
| Molding Temperature, F | 350 |
| Molding Time, min | 5–20 |
| Afterbake | Not normally required |
| Mold Shrinkage, % | 0.0–0.0035 |

## New Silicone Rubber Has High Strength, Tear Resistance

Two new silicone rubber compounds possessing high strength and improved tear resistance have been developed by *Connecticut Hard Rubber Co.*, 407 East St., New Haven, Conn. Tensile strengths ranging from 1000 to 2000 psi and tear strengths of 200 to 300 lb per in. are claimed for Cohrlastic HT Molding 400 and HT Extrusion 600 compounds. This additional strength has been added to the normal characteristics of silicone rubbers, such as resistance to weathering and ozone and high dielectric strength. Elongation is said to range from 400 to 800% and abrasion resistance is said to be good. The compounds are available in sheets, molded parts and fabricated articles.

*(More New Materials on page 144)*

THE NEW MATERIAL may be molded in a variety of shapes.

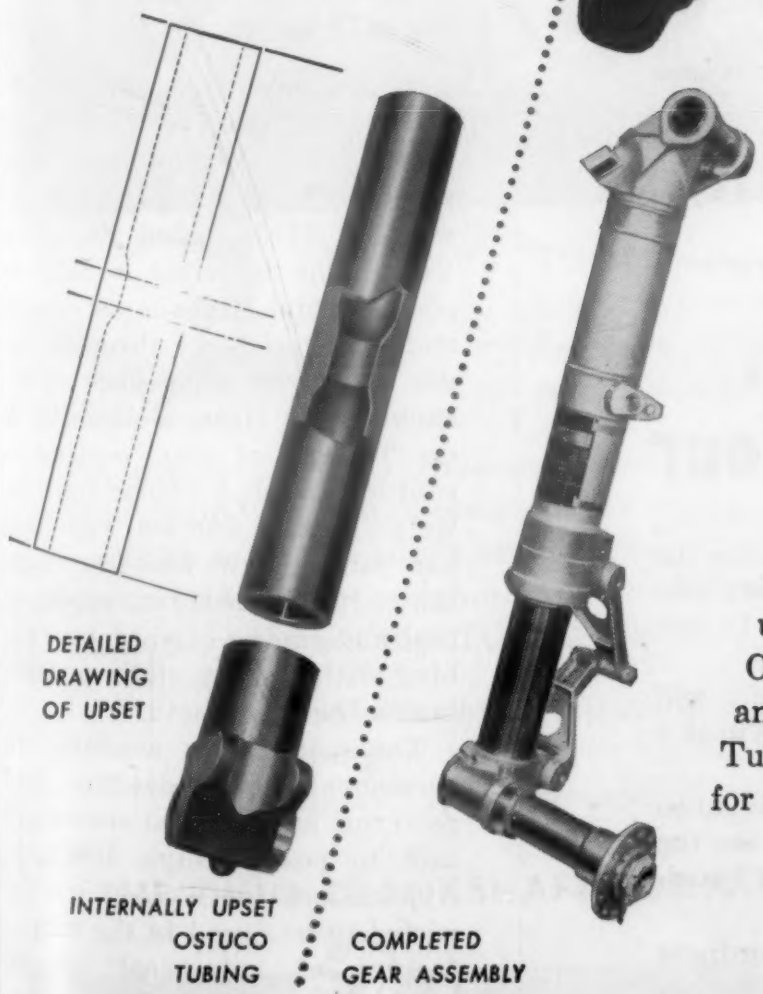
**PHYSICAL PROPERTIES OF COHRLASTIC HT**

| | MOLDING HT 400 | EXTRUSION HT 600 |
|---|---|---|
| UNAGED | | |
| Ten Str, psi | 1400–2000 | 700–1100 |
| Elong, % at break | 700–850 | 350–800 |
| Hardness, Shore "A" Durometer | 50–60 | 40–60 |
| Tear Resistance, lb/in. | 225–300 | 175–275 |
| AGED, 70 hr at 300 F | | |
| Ten Change, % | −20 | +30 |
| Elong Change, % | −25 | −40 |
| Hardness Change, points | +15 | +10 |
| AGED ASTM OIL NO. 1, 70 hr at 300 F | | |
| Ten Change, % | −60* | −35* |
| Elong Change, % | −60* | −75* |
| Hardness Change, points | +15 | +25 |
| Vol Increase, % | +5 | +7 |
| AGED, 70 hr at 212 F, under compression | | |
| Comp Set, % | 22 | 24 |

** Typical tests after Aging, 70 hr at 300 F in ASTM Oil No. 1—Tensile Strength, psi 600; Elongation, % 300; Hardness, Shore "A" Durometer 70.*

*NOTE: Low Temperature Flexibility—Molding HT 400 passes at −65 F. Extrusion HT 600 passes at −100 F*

# OSTUCO internally upset tubing processes faster




Landing gears, manufactured by The Cleveland Pneumatic Tool Company for North American Aviation's F-86H, have piston tubes machined from internally upset OSTUCO tubing. The upset construction of these *special-quality* OSTUCO tube forgings keeps machining to a minimum and permits faster processing. Savings are 25% . . . or $4.95 per unit.

*Special-quality* OSTUCO tubing produces stronger, lighter products . . . better looking products at greater savings. Its uses are practically unlimited. Wherever you use tubing *in any form*, OSTUCO's single source service can save you time and money. Write for helpful booklet "Ostuco Tubing," or better still, send us your blueprints for immediate quotation.

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# Wilson "Rockwell"* Hardness Testers

## SET-O-MATIC* DIAL GAUGE

Eliminates human error. Operator merely applies minor load and taps depressor bar. No setting of dial to zero.

### OTHER FEATURES

- Major load applied under dash pot control
- Illuminated Dial Gauge
- Major load removed by motor
- Illuminated Penetrator

# Eliminates Operations... Increases Tests per Hour

All you have to do with the Model Y WILSON "ROCKWELL" Motorized Hardness Tester is apply the minor load and tap the major load depressor bar. The machine does everything else automatically. The cycle of Major Load operation may be less than 2 seconds.

This speed of test means great savings in time which will reduce your hardness testing costs. Yet it is done to Wilson's high standard of accuracy.

The utter simplicity of setting the SET-O-MATIC* dial gauge eliminates human error. The operator does not have to set the dial. The large pointer is automatically brought to "SET" position when the minor load is applied.

The Model Y Motorized WILSON "ROCKWELL" Hardness Tester is in production and orders are being accepted for early delivery. Write today for descriptive literature and prices.

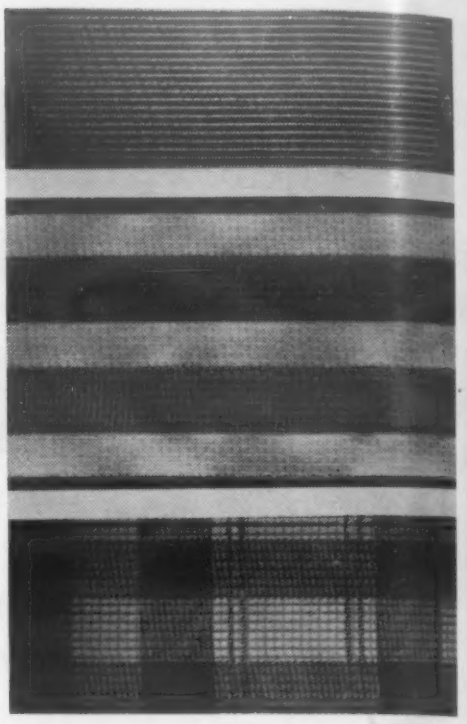
*Trade Marks

ACCO
Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-E Park Avenue, New York 17, N. Y.
TRADE MARK

plus BRALES and TUKON

For more information, turn to Reader Service Card, Circle No. 419


# New Materials, Parts, Finishes



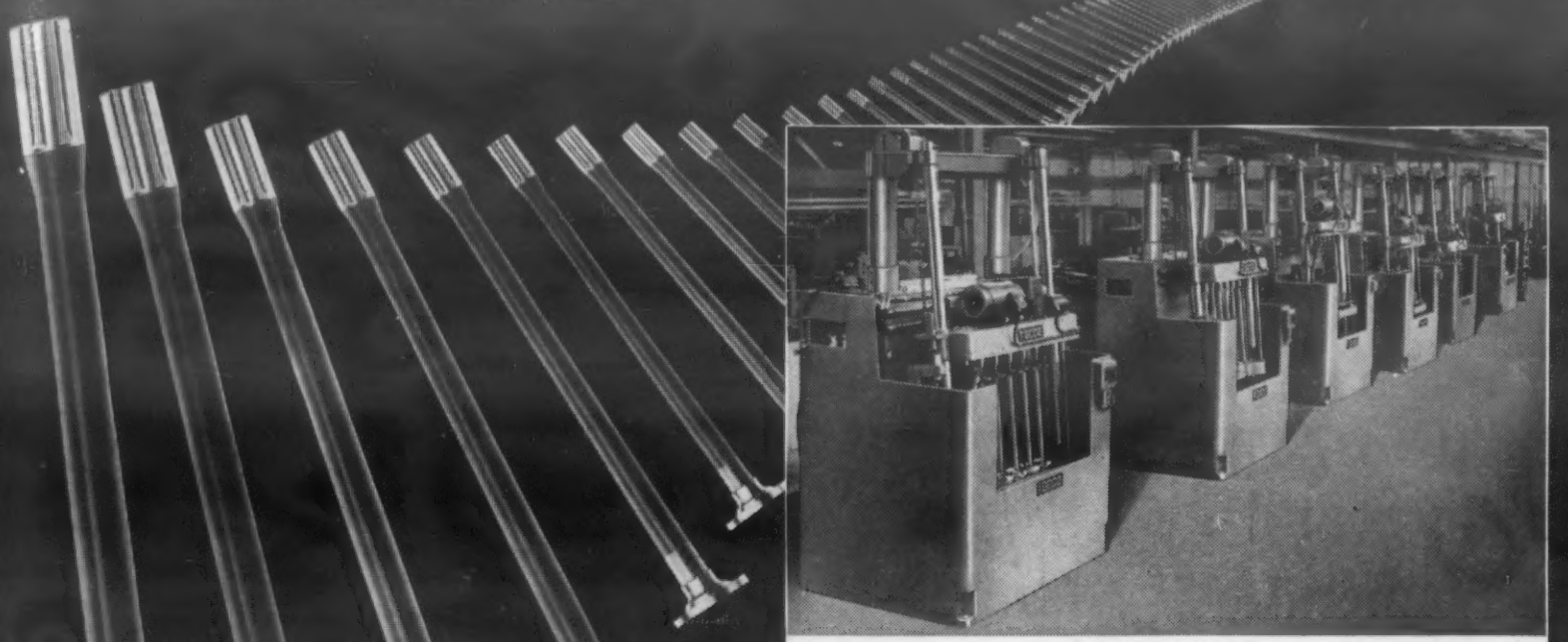
## Vinyl Coated Glass Cloth Has High Tear Resistance

A new high-strength, waterproof vinyl covered glass fiber fabric called Weblon has been marketed by *S. L. Chambers Associates*, 11 W. 42nd St., New York. The material is said to possess high tensile strength and tear resistance through the use of woven glass fiber cloth, supplied by Hess, Goldsmith & Co. The use of vinyl coating is said to provide a fabric light in weight, water and soil repellent and sun, mildew, and fire resistant. It will not rot, crack or peel and can be cleaned by rubbing with a damp cloth, according to the manufacturer.

The material is available in permanent color designs and patterns, and stitched seams are said to possess high strength. Applications for Weblon are expected to be found in the manufacture of auto seat covers, tents, boat covers, tarpaulins, chemical containers, industrial and work clothing, awnings, and other products now employing dyed drill or conventionally coated fabrics. It is available in widths of 48 to 54 in.

*(More New Materials on page 146)*

# Ten Million TOCCO*-Hardened Axle Shafts





Battery of TOCCO machines for hardening automotive axle shafts. TOCCO*-hardened shafts show an increase of up to 200% in resistance to torsional fatigue over furnace-hardened shafts made of alloy steel.

## Give Super Service to American Motorists

*... Save Manufacturers $2,000,000*

The application of TOCCO* Induction Heating to the surface hardening of rear axle drive shafts for passenger cars and trucks provides a fine example of how a less expensive manufacturing method often results in the best possible end product.

For instance, TOCCO* Induction Hardening permits the substitution of easier machining carbon steels for expensive alloys, saving from 25¢ to 55¢ per car in material costs alone. Additional savings result from the fact that TOCCO eliminates the need for annealing, tempering and shot peening operations formerly required. Moreover, long hauls to and from the heat-treating department are eliminated because cool, clean TOCCO* fits right in the production line—next to related operations.

If you make parts that require hardening, annealing, brazing, or heating for forging or forming, it can pay you handsome dividends to investigate TOCCO* Induction Heating as a sound method of improving product quality *while reducing costs.*

**THE OHIO CRANKSHAFT COMPANY**

**TOCCO**

*Trade Mark Reg.

*Mail Coupon Today*

**NEW FREE BULLETIN**

THE OHIO CRANKSHAFT CO.
Dept. T-1, Cleveland 1, Ohio
Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

Name_____
Position_____
Company_____
Address_____
City_____ Zone____ State_____

* For more information, turn to Reader Service Card, Circle No. 358

## You can be sure

you're planning your production properly if you've considered the advantages of

## Marblette Plastic Tooling Resins

which can speed designs from drawing board to production run, require no heavy equipment investment or highly skilled labor, facilitate pilot runs and design changes, and

## will save you up to 70% in time and up to 80% in cost

in making stretch dies, draw dies and panels, match dies, jigs, fixtures, patterns, models, prototypes, core boxes, plating shields, bag and contact molds, latex dip production forms, molds for fibrous glass lay-up, spray-metal backing, vacuum-forming, and electro-forming, and other types of tools and dies.

The versatile yet specialized liquid epoxy and phenolic resins developed by Marblette fit into your production picture. Convince yourself—see how they can give you increased economy and efficiency—use the handy coupon below for resin samples, technical data, a phenolic data folder, an epoxy data folder, and a conversion computer that shows at a glance how much resin to use for casting any size product or part.

**Marblette**

The Marblette Corporation
37-11 Thirtieth Street
Long Island City 1, N. Y.
We are interested in plastic tooling for

.....

Please send us free
- ☐ Technical Literature
- ☐ Phenolic Data Folder
- ☐ Epoxy Data Folder
- ☐ Conversion Computer

Name.....

Title.....

Company.....

Address.....

For more information, Circle No. 333


# New Materials, Parts, Finishes

## Blue Asbestos Provides High Heat and Acid Resistance

South African Blue Asbestos which is said to provide high resistance to temperatures and chemicals, combined with exceptional physical and mechanical properties is now available in this country through the *North American Asbestos Corp.*, Board of Trade Bldg., Chicago 4, Ill. Also known as Crocidolite asbestos, the material is said to have the smallest fiber diameter—down to ⅓ of a micron—of any fibrous material. Fiber length is said to be greater than that of the most costly grades of white asbestos.

Blue Asbestos is unaffected by temperatures up to 750 F, and may be used at higher temperatures for some applications. It has high resistance to acids, caustics, and other corrosive chemicals, and possesses high strength. The high strength and modulus of elasticity (over 30 million psi) of the fibers make them suitable as reinforcing for plastics and such materials as asphalt and pavings, or as a binder for cement and mortar.

The material is available as loose fibers, corded rovings, rope, yarns, woven cloths, folded tapes, braided and twisted packings, millboard and compressed gasket sheet.

## Neoprene Sheet Lining Has Abrasion, Corrosion Resistance

A new neoprene prevulcanized sheet lining which is said to provide high abrasion resistance and protection against acid and alkali corrosion has been marketed by the *Carboline Co.*, 331 Thorton Ave., St. Louis 19, Mo. Called Neoprene #750 Sheet Lining, the material can


PANGBORN BLASTS by don herold

When those small metal parts call out, "Hey, cleaning time!"
And you have to remove scale, old paint, rust or grime . . .

You can clean them in seconds and save money, too —
Pangborn's Blast Cleaning Cabinet's made just for you.

It produces a finish so smooth and so clean,
It will do the best job that you ever have seen.

**Pangborn Blast Cleaning Cabinet**

for efficient, low-cost cleaning of metal parts. Cleans pieces up to 35" x 60" in size. Models from $319 and up.

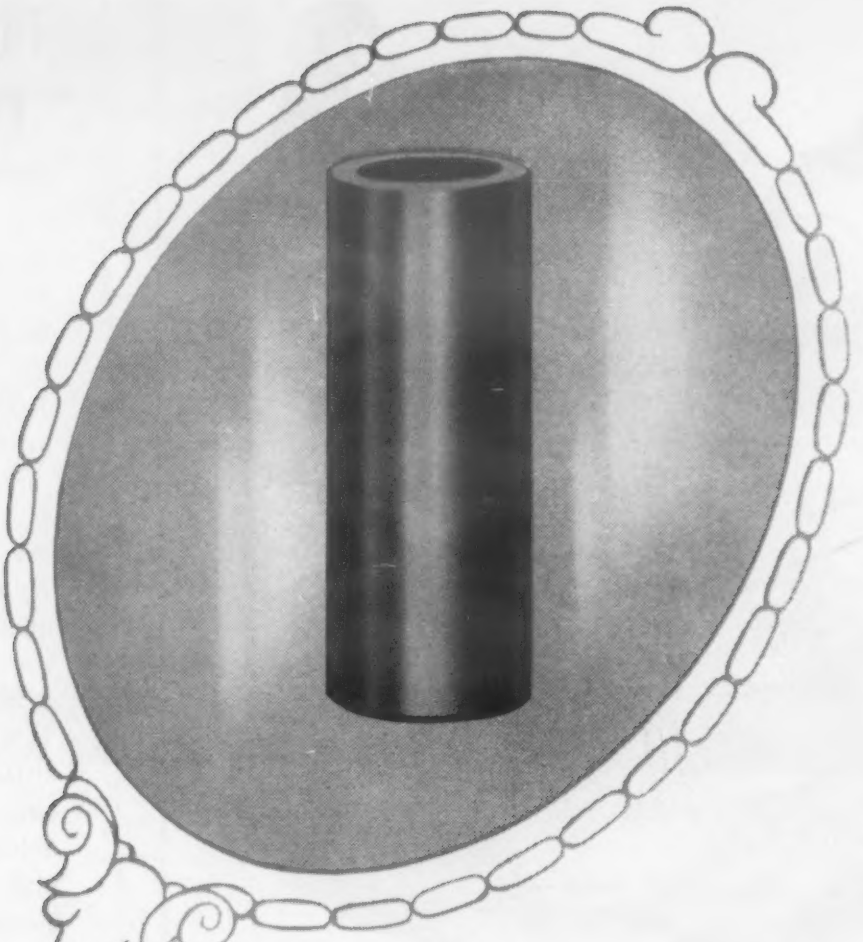
For details, write:
PANGBORN CORP., 1700 Pangborn Blvd., Hagerstown, Maryland

**Pangborn**

BLAST CLEANS CHEAPER
with the right equipment for every job

50th Anniversary Medallion

For more information, Circle No. 345



# reflecting the quality

The one single thing that mirrors the quality of your product most is the careful selection of the components used. That's why it's such a sound plan to specify Wolverine tubing in your design.

Take, for example, Wolverine's large-diameter commercial copper and brass tubing. It is of typical Wolverine quality—a product of Tubemanship. You can expect fast delivery on straight lengths in diameters up to 4½" O.D. and coils up to 1⅜" O.D.

You'll find the up-to-the-minute story in Wolverine's commercial tube book. Write for it today. WOLVERINE TUBE, 1489 Central Avenue, Detroit 9, Michigan.

EST. 1916

**WOLVERINE TUBE**

DIVISION OF CALUMET & HECLA, INC.

*Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes*

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

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* For more information, turn to Reader Service Card, Circle No. 457

"HANDS" THAT HELP MOVE THE EARTH!

. . . those unseen hands that put action into the earth moving giants . . . the hundreds of shapes and sizes of steel castings that make up excavating and mining machinery. Hands that are unnoticed and are subject to shock, stress and abrasion . . . all examples of Unitcasting's dependability.

Gears, cams, rockers, sheaves, stanchions, levers, protective housings, and many other parts made to exacting standards . . . subject to rigid inspections. Foundry engineered Unitcastings are the answer when the going gets rough!

Assured dependability in parts? Specify Unitcastings! Unitcast's representative is as convenient as your telephone. Call today!

UNITCAST CORPORATION • Toledo 9, Ohio

*In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec*

**Unitcast**

QUALITY STEEL CASTINGS

For more information, turn to Reader Service Card, Circle No. 357

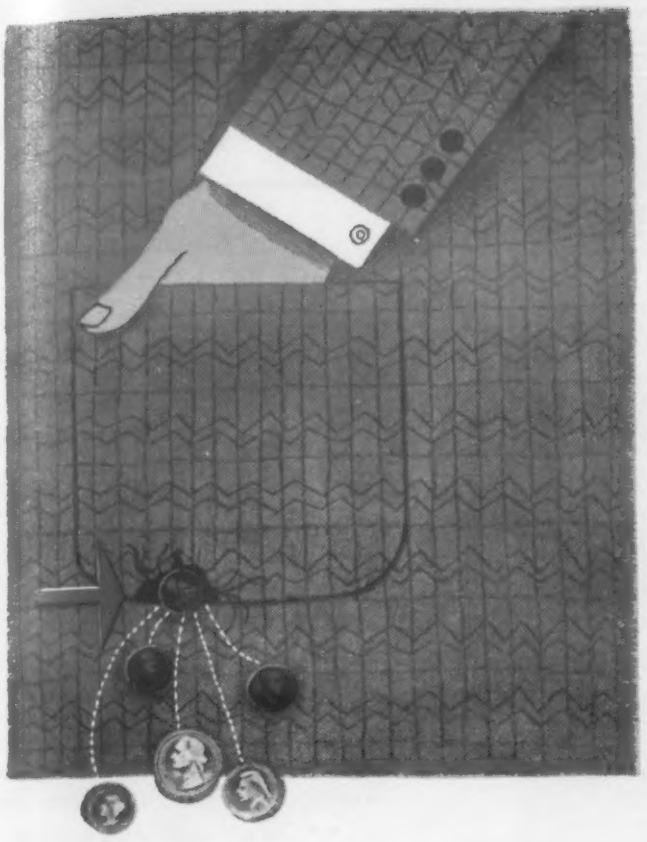

# New Materials, Parts, Finishes

be applied in the shop or field and is supplied in rolls 32 to 34 in. wide in varying lengths. It is available in thicknesses of 1/16, ⅛ and 3/16 in. depending on the service requirements.

For bonding the sheet to metal surfaces or to itself, the manufacturers recommend their Neoprene Adhesive F-1, a 1-package material which requires the addition of no solvents or catalysts prior to application. The sheet lining is said to be suitable for use in transportation, storage and handling of acids, plating solutions, alkalies and various inorganic salt solutions at temperatures up to 190 F. It is also recommended for the lining of coal bunkers, agitating and mixing equipment, and coal and gravel chutes.

## Thin Glass Fabric Coated With Silicone Rubber

A new thin, light-weight, silicone rubber-coated fabric, in thicknesses of 0.007 and 0.010 in. has been developed by the *Connecticut Hard Rubber Co.*, 407 East St., New Haven, Conn. Called Cohrlastic 2804, the material weighs 4.5 oz per sq yd, has a dielectric strength of 1100 to 1400 v per mil, a useful temperature range from -70 to 500 F, and is flexible and rubbery,



a hole here costs money...

a hole here saves money

***Crucible Hollow Tool Steel Bars*** put savings into the pockets of the metalworking industry. There's no need for costly drilling, boring, cutting-off or rough-facing operations. For the hole is already in the steel you buy. You save production time, machine capacity—avoid scrap losses.

Crucible Hollow Tool Steel Bars are now available in any of our famous tool steel grades . . . in almost any combination of O.D. and I.D. sizes. And you get *immediate* delivery of five popular grades — KETOS oil-hardening, SANDERSON water-hardening, AIRDI 150 high-carbon high-chromium, AIRKOOL air-hardening, and NU DIE V hot-work tool steels.

Your Crucible representative can show you how to save time and money with Crucible Hollow Tool Steel Bars. *Crucible Steel Company of America, Oliver Building, Pittsburgh 30, Pa.*

**CRUCIBLE** first name in special purpose steels

**Crucible Steel Company of America**

* For more information, turn to Reader Service Card, Circle No. 412

*LET US QUOTE ON YOUR TUBING AND FABRICATION NEEDS*

Avon single wall steel tubing is successfully supplanting other types of tubing—aluminum, brass, copper and steel—with equal or improved reliability of performance and really impressive economies.

Avon's High Frequency Fusionweld process insures a much higher degree of tensile strength, greater resistance to vibration and fatigue, extreme ductility, plus greatly improved adaptability in producing the most critical tube forms—such as beading, bending, coiling, flaring, knurling, slotting, piercing, threading and swaging without cracking, tearing or checking.

Avon engineers can assist with your tubing problems and help point up cost saving advantages. Why not write, or submit blueprints for quotations.

*3/16" O.D. to 3/4" O.D.*
*PLAIN OR TERNE COATED*

***A few of the hundreds of Fusionweld Tubing applications***

**AUTOMOTIVE**
Gas lines & vents
Brake lines
Hydraulic window & seat lifts
Chassis tubes
Radiator overflow
Choke controls
Oil return lines
Dip stick tubes
Oiler tubes
Automatic transmission

**FARM EQUIPMENT**
Hydraulic lifting devices
Support tubes
Lubrication lines
Fuel lines
Fuel manifolds

**ELECTRICAL**
Ceiling & wall fixtures
Lamp tubes
Heating elements
Radio & TV antennae

**HEATING**
Oil & gas lines
Pilot tubes
Flash tubes
Pot burner tubes
Fuel tank tubes

**TOYS—FURNITURE**
Scooter & wagon parts
Spacers
Pop guns
Bicycle parts
Mechanical toys
Tables
Chairs
Swings
Baby carriages, cribs, car seats and beds

**MISCELLANEOUS**
Umbrellas
Display boards
Panels
Conveyor oil lines
Lawn mower handles
Hose reels

AVON TUBE DIVISION

HIGBIE MANUFACTURING CO.

ROCHESTER MICHIGAN

For more information, turn to Reader Service Card, Circle No. 376


# New Materials, Parts, Finishes

according to the manufacturer. The glass fabric base is 0.001-in. cloth. The coated material is recommended for use as electrical insulation, gasketing, sensitive diaphragms, or for aircraft septum material.

## Silicone-Glass Laminate Has High Strength at 400 F

Silicone resins have been combined with woven glass cloth to provide a laminate which will withstand constant temperatures of 400 F without affecting mechanical or electrical properties, according to the manufacturers, the *Synthane Corp.*, Oaks, Pa. Designated Synthane grade G-7, the material is said to be dimen-

**TYPICAL PROPERTIES OF SYNTHANE GRADE G-7**

| | |
|---|---|
| Ten Str, psi | |
| Lengthwise | 23,500 |
| Crosswise | 18,500 |
| Comp Str, psi | |
| Flatwise | 45,000 |
| Edgewise | 14,000 |
| Flex Str, psi (1/16 to 1/8 in. thick) | |
| Lengthwise | 20,000 |
| Crosswise | 18,000 |
| Mod of Elast in Flex, psi | |
| Lengthwise | 1,400,000 |
| Crosswise | 1,200,000 |
| Izod Imp, ft-lbs/in. of notch | |
| Flatwise | 6.5 |
| Edgewise | 5.5 |
| Rockwell Hardness, M Scale | 100 |
| Sp Gr | 1.68 |
| Coef of Therm Lin Exp, cm/cm/°C | $1.0 \times 10^{-5}$ |
| Water Absorption, % 24 hr | |
| 1/32 in. | 0.68 |
| 1/16 in. | 0.55 |
| 1/8 in. | 0.35 |
| Dielectric Str, vpm Perpendicular to laminations | |
| Short time test | |
| 1/32 in. | 450 |
| 1/16 in. | 400 |
| 1/8 in. | 350 |
| Dissipation Factor | |
| 1 megacycle, Cond. A* | 0.003 |
| 1 megacycle, Cond. D—24/23** | 0.050 |
| Insulation Resistance, megohms | |
| Condition: 96 hr, 90% relative humidity, 95 F | 2500 |
| Arc Resistance, sec | 180 |
| Maximum Constant Operating Temp, F | 400 |

** As received, no special conditioning,*
*** Immersed in distilled water at 23 C for 24 hr.*

# PERHAPS WE'LL HAVE TO ADD A PINCH, FOR YOU...

Just ask us for an alloy we haven't got — we'll be delighted.

Because that's how each of the more than 80 resistance and electronic alloys Driver-Harris makes had its beginning. Each of these highly specialized alloys is custom-made . . . produced exactly to the specifications of our customers.

The physical and chemical properties of an electrical resistance alloy can be altered greatly by a minute difference in its constituents. Often just a few ounces to the ton can make the difference you need.

One thing you can always rely on in any Driver-Harris alloy: it is made to the most precise metallurgical checks and controls known to the industry. It is these exclusive quality controls that have made Nichrome V and Nichrome* the standard for over 50 years by which all other electrical resistance alloys are measured.

Perhaps in a sense Nichrome is *too* well known. For we don't want people to forget that we make many other resistance alloys of sustained high quality to meet other special needs. And that, as we said at the outset, our engineers will be more than delighted to start afresh tomorrow to devise a new one, custom-made for you. Just tell us as exactly as you can what you wish to accomplish.

*NICHROME V and NICHROME are manufactured only by*

## *Driver-Harris Company*

**HARRISON, NEW JERSEY**

**BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco**

**In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario.**

*T. M. Reg. U. S. Pat. Off.

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

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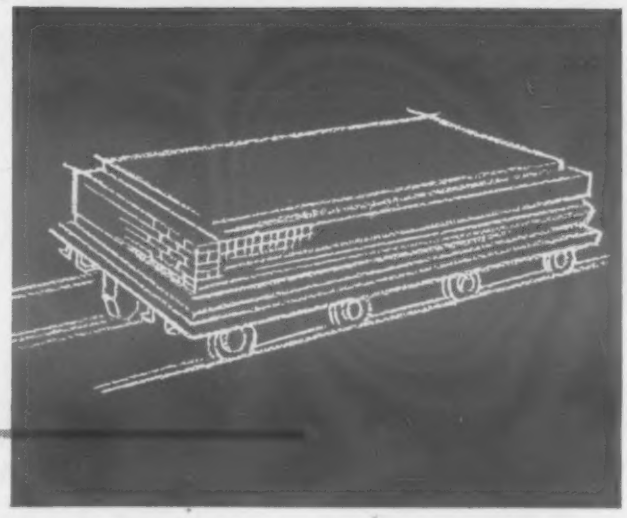
# HOLCROFT and the CAR-TYPE FURNACE



Car-type furnaces solve the problem of heat treating large, awkward-to-handle stock—or large quantities of parts which together form a bulky, heavy load.

Furnaces of this type can be either batch or continuous. In the first case, the load is rolled into the furnace and left there until the heat treat cycle is completed. When several cars are placed in line—the last one added pushing the row of cars through the furnace zones—the operation is continuous.

This is just one major classification of stock handling. Actually, there are several others—each to be considered when selecting a furnace to do a job. This is the type of flexibility you find when you turn your heat treat problems over to Holcroft. Only here do you get the personalized attention—the custom engineering—that slashes your costs and makes possible new standards in quality control.

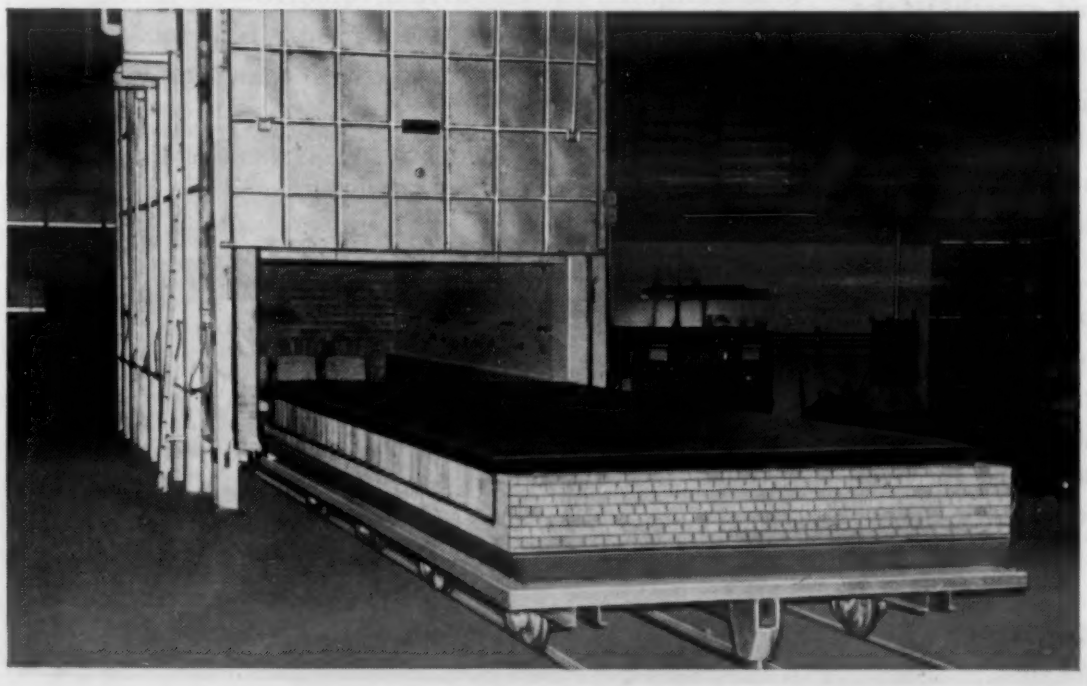
Holcroft's new book "Blazing the Heat Treat Trail" is jam-packed with the various factors governing the selection of a heat treat furnace. But, see for yourself—write for your copy —today! Holcroft & Company, 6545 Epworth Blvd., Detroit 10, Mich.

BUILT BY HOLCROFT & COMPANY DETROIT · MICH.

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

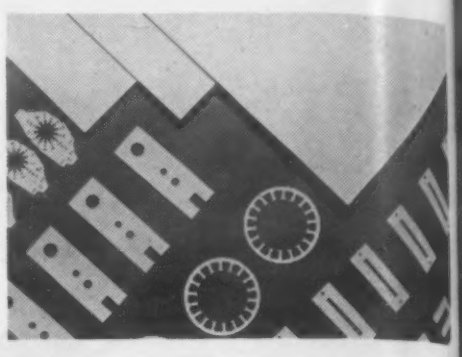
CHICAGO, ILL. CLEVELAND, OHIO HOUSTON, TEXAS PHILADELPHIA, PA.

CANADA: Walker Metal Products, Ltd., Windsor, Ontario EUROPE: S.O.F.I.M. Paris 8, France



For more information, turn to Reader Service Card, Circle No. 336


# New Materials, Parts, Finishes



sionally stable, combining high mechanical strength with high dielectric strength, arc resistance, and low water absorption. Grade G-7 is available either in sheet form or fabricated to specification. It is particularly suited to electrical and electronic applications where high ambient or operating temperatures are encountered. It is manufactured to conform to MIL-P-997, type GSG.

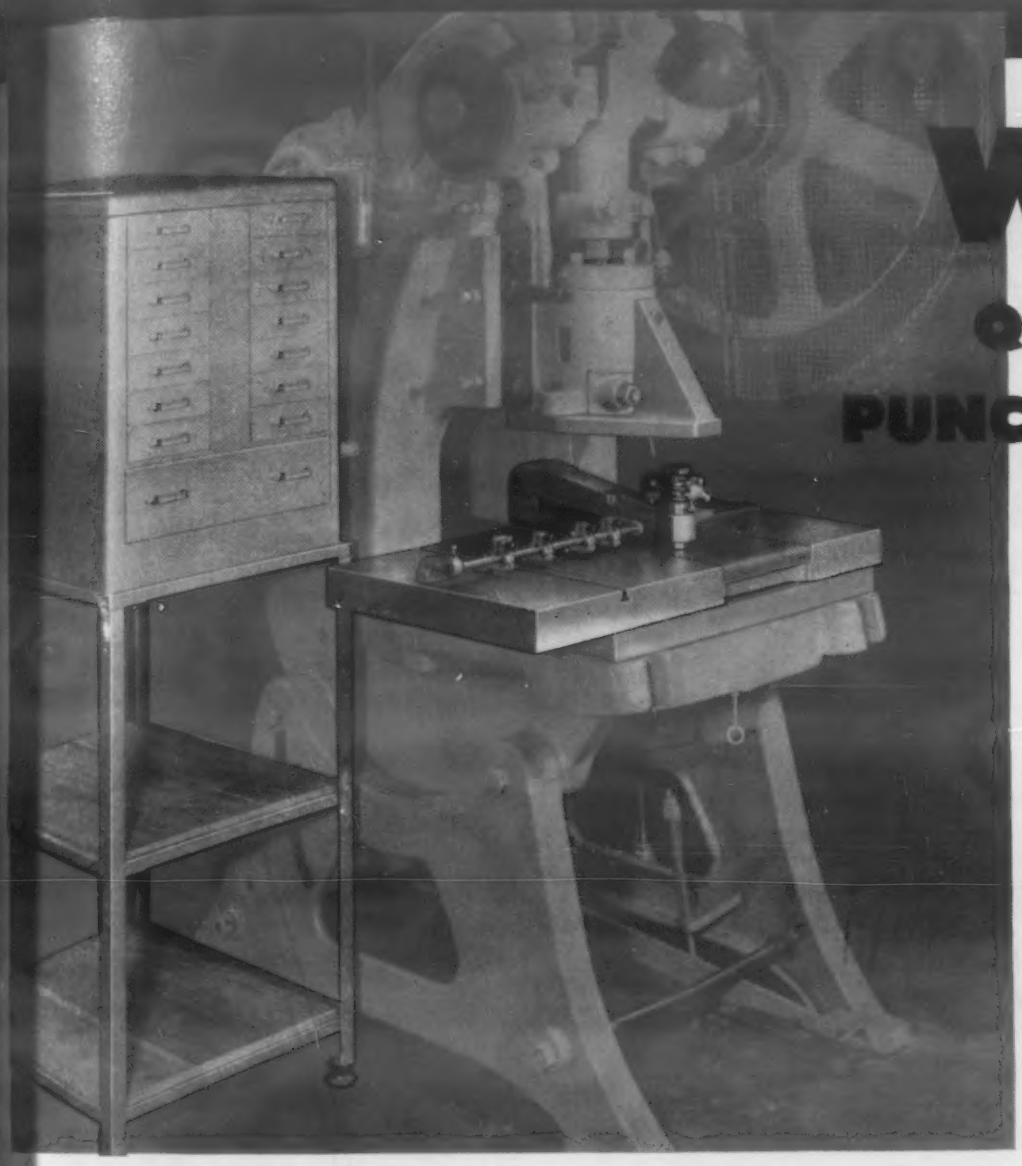
## Punching Grade Phenolic Cuts Cost

A new punching grade phenolic laminate is said to provide exceptional cold punching qualities at a lower cost than comparable industrial laminates. It provides high cold punching and shearing qualities combined with good mechanical and electrical strength, according to the manufacturer, The *Laminated and Insulating Products Dept., General Electric Co.*, Coshocton, Ohio. Designated G-E Textolite Grade 11561, the material can be punched cold to ⅛ in., and sheared cold to 3/32 in.

A new hot punching laminate, Grade 2053, is also available at a reduction in cost. It is said to incorporate high mechanical strength with good electrical values and a uniform appearance. It can be fabricated in thicknesses up to ⅛ in. and is said to be suited to applications such as terminal strips, sockets, spacers and contractors.

*(More New Materials on page 154)*

# Announcing



## WALES
## QUICK-CHANGE PUNCHING & GAUGING ASSEMBLY

Showing how easily and quickly the punch and die is removed and replaced in the Wales Quick-Change Holder for punching holes up to 1¼" in diameter. To remove the die, pull the holder forward and hit the punch head with hand which releases the ball-held die from bottom of holder. Punch assembly is merely lifted out of top of holder.

Showing Wales 3½" Holder for punching holes up to 3½" in diameter. This holder is not part of the "PPG Group" but is available as optional equipment.

Converts presses into a versatile hole punching machine with **20 SECOND PUNCH AND DIE CHANGE**

This new, self-contained press accessory pays for itself in a matter of a few months...in some cases in a matter of weeks by such unusual time saving advantages as changing punches and dies in 20 seconds. Holder keeps punch and die in permanent alignment. Built-in adjustable gauging provides a new, simple, fast, accurate method of locating the work.

Popularly known as the Wales "PPG Group", it consists of a bed plate, quick-change holder, 18" back gauge bar, 18" stop support rail and a combination punch storage cabinet and tool rack.

This is too BIG a story to tell in this space, so write for illustrated PPG Bulletin.

**WALES-STRIPPIT CORPORATION**

George F. Wales, Chairman

399 Payne Avenue, North Tonawanda, N. Y.

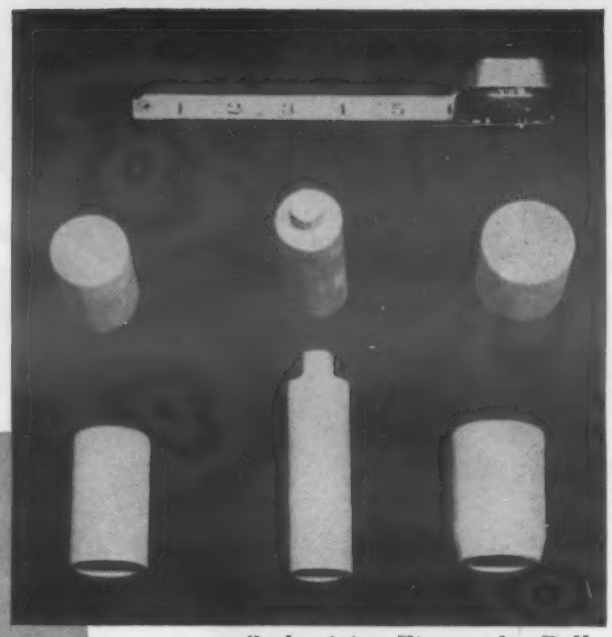
(Between Buffalo and Niagara Falls)

WALES-STRIPPIT OF CANADA LTD., HAMILTON, ONTARIO

For more information, turn to Reader Service Card, Circle No. 416

# Small

HIGH ALLOY
CASTINGS

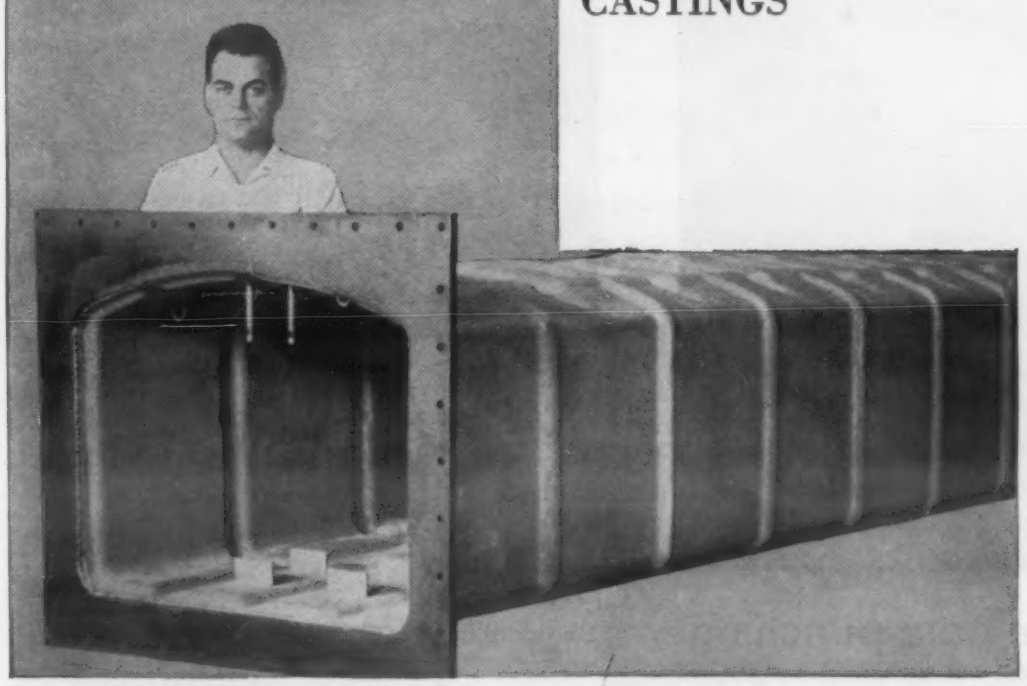


Carburizing Fixture for Ball Bearings 1½" diameter—
Analysis 35% Ni — 15% Cr

DURALOY

# Large

HIGH ALLOY
CASTINGS



Muffle for Continuous Strip Annealing
12' 6" long — Analysis 38% Ni — 18% Cr.

**LARGE or small DURALOY, can do it! These are just typical examples of the work moving through our foundry. Some of these castings are designed for heat resistance, some for corrosion resistance, some for abrasion resistance; all are cast by experienced foundrymen. All are carefully tested in our up-to-date laboratory.**

**If you have a high alloy casting problem . . . LARGE or small, we can help you. For more information, send for Bulletin No. 3150-G.**

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • Eastern Office: 12 East 41st Street, New York 17, N.Y.

Detroit Office: 23906 Woodward Avenue • Pleasant Ridge, Mich

Atlanta: J. M. TULL Metal & Supply Co. — Chicago: F. O. NELSON 332 S. Michigan Avenue

METAL GOODS CORP.: Dallas • Denver • Houston • Kansas City • New Orleans • St. Louis • Tulsa

For more information, turn to Reader Service Card, Circle No. 389


# New Materials, Parts, Finishes

## Improved Corrosion-Resistant Coating

An improved acid and alkali resistant black paint, said to reduce the number of coatings necessary, has been marketed by *Speco, Inc.*, 7308 Associate Ave., Cleveland 9. The new formula contains silicone materials, adding to the water repellence and luster of the coat.

Called Chem-Rem, the material is recommended for both interior and exterior use on metal, masonry or wood. It is said to withstand attack by acetic and hydrochloric, dilute sulfuric, or mixtures of these acids. It also protects against severe action of bleaching solutions, dilute caustic soda, ammonia and other alkalines. It is particularly recommended for locations where smoke and chemical fumes are found. The cured coat is said to be elastic, impervious to moisture and unaffected by changes in temperature. It can be applied by brush, spray or dip and dries to a glossy black finish in 3 hr, fully curing in 10. It is intended to be a finish coat, and will bleed through other paints.

Typical uses for the material are found in the electroplating and chemical industries for tanks, stacks, ventilating hoods, conveyor arms, roofs, siding, gutters, sheathing, sewage equipment, standpipes, etc.

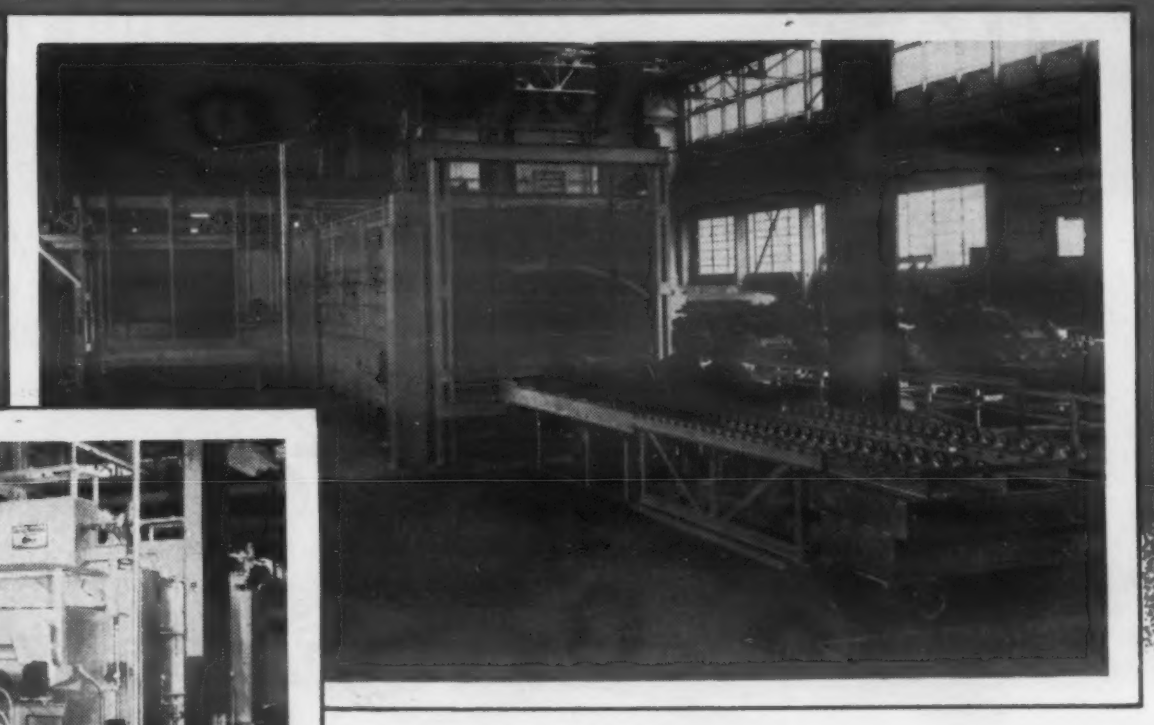
## High Conductivity Beryllium Copper Wire

A new high conductivity beryllium copper alloy wire with a composition of 0.5 beryllium, 2.5% cobalt and the balance copper has been developed by *Little Falls Alloys*, 194 Caldwell Ave., Paterson, N.J. Called Silvercote No. 10 Alloy, the wire is said to have 65-70% of the

# Heat Treating . . .

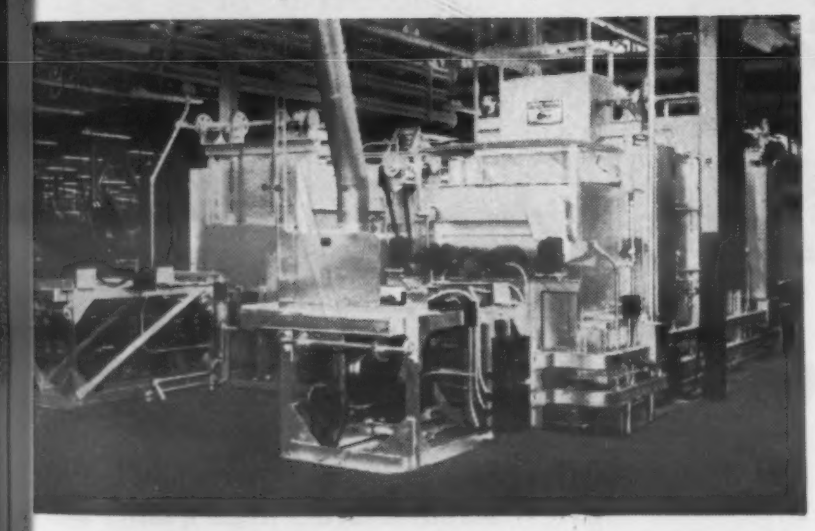
## *Automatically*

FROM FIRST HEAT TO HEAT TREAT, LOFTUS BUILDS 'EM BETTER



Automatic, continuous heat treat line for hardening, quench, and draw of steel wheels designed and built by Loftus.

Automatic, continuous heat treat line for hardening, quench, and draw of small automobile parts designed and built by Loftus.



*Send today* for 16 page Booklet:
"Proven Heat-Treating Efficiency by Loftus."
Shows many furnace types.

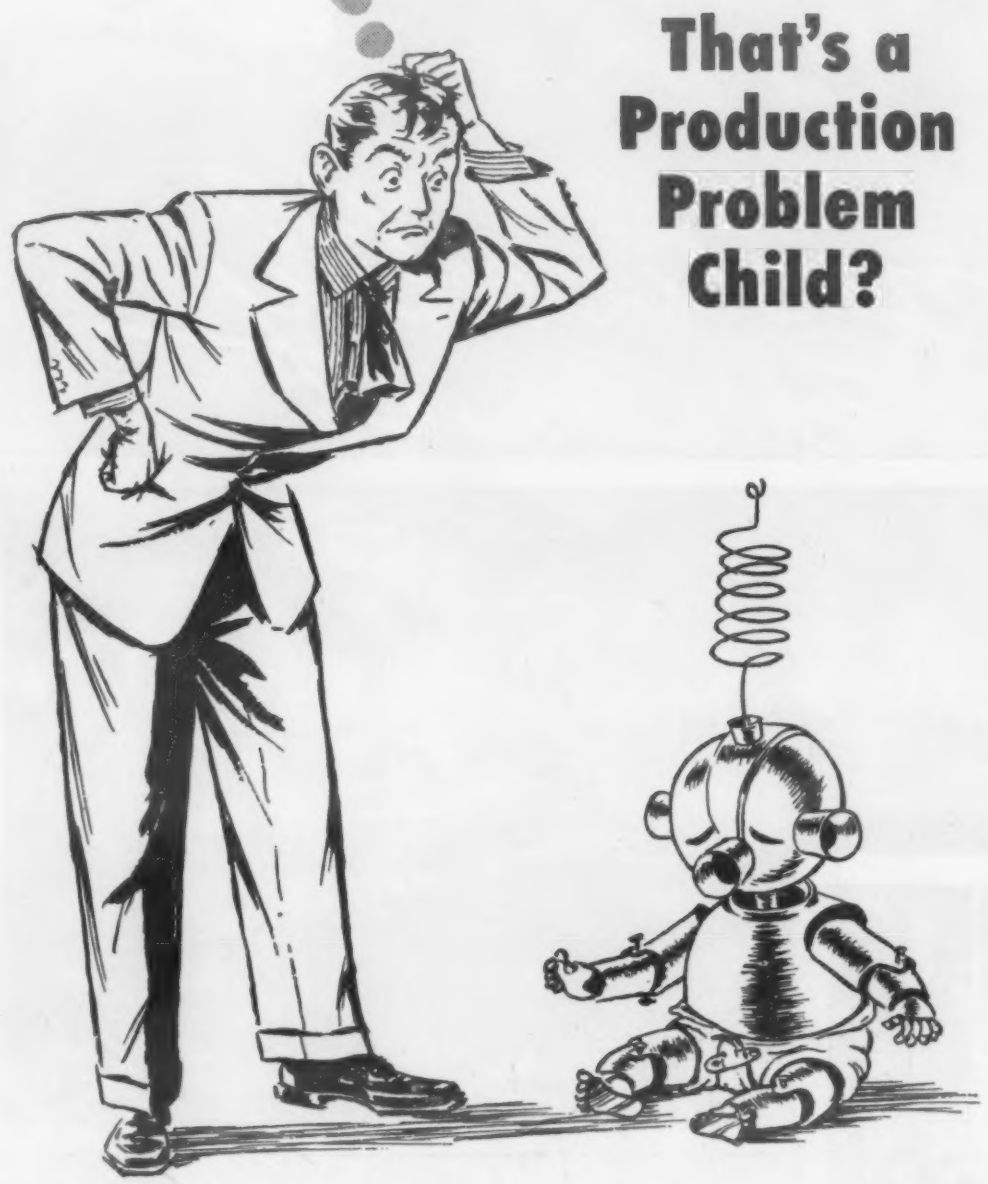
Loftus Continuous Heat Treat Lines offer efficient design for handling your product by tray, where the product is loaded and unloaded at one point. Direct, or atmosphere control type furnaces are engineered to render economical, automatic heat treating service. The "Pin-Point Quench" and washer is completely automatic. Construction of "in-line," "square," or rotary layout is dependent upon your individual requirements. Practical, *one operator* units can be built for loads of from 500 to 6000 pounds per hour.

**Loftus ENGINEERING CORPORATION**
Designers and Builders of Industrial Furnaces

610 Smithfield Street, Pittsburgh 22, Pennsylvania

• For more information, turn to Reader Service Card, Circle No. 469

# Do You Have a New "Baby"



## That's a Production Problem Child?

## Let GEOMETRIC Help You Out

Many a brainchild dies at the design stage because of a lack of proper production facilities to turn a dream into a profitable reality. Geometric Stamping Company has the production experience and equipment to transform your new product idea from blueprint to finished product . . . quickly and profitably. We're equipped to make a part, an assembly or your whole new product.

*Write today for free booklet—"Geometric Craftsmanship"*

**GEOMETRIC STAMPING CO.**
1145 E. 200th St., Cleveland 17, Ohio

ONE OF THE 16 INTEGRATED COMPANIES
BARIUM STEEL CORPORATION
WORKING IN STEEL, ALUMINUM MAGNESIUM, FIBERGLASS

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# New Materials, Parts, Finishes

conductivity of copper and will resist fatigue from flexing and vibration and withstand higher temperatures than ordinary copper wire. The material is lightly plated with silver, aiding solderability. The plating also makes it possible to apply new insulating materials requiring higher curing temperatures than tinned wires can withstand. It is available in all fine wire gages in solid or stranded form.

## Activated Steel Wire for Inert-Gas Welding

An activated mild steel wire has been marketed for use with the Aircomatic inert gas arc welding process by *Air Reduction Sales Co., Div. of Air Reduction Co., Inc.*, 60 E. 42nd St., New York 17. The activation agents are said to change the burn-off rate so that stable spray-type transfer can be obtained on d.c., straight polarity without oxygen additions to the shielding gas. The wire also permits use of the welding process with standard a.c. welding power supplies. According to the manufacturer, high quality and speed of the basic process can now be realized where severe arc blow conditions previously prevented its use.

## Hydrocarbon Gives Rubber High Resistance to Oils, Solvents

A new hydrocarbon, designed to provide elastomeric materials with a high degree of resistance to petroleum oils and solvents and a minimum of dimensional variations, has been developed by the *Barrett Div., Allied Chemical*

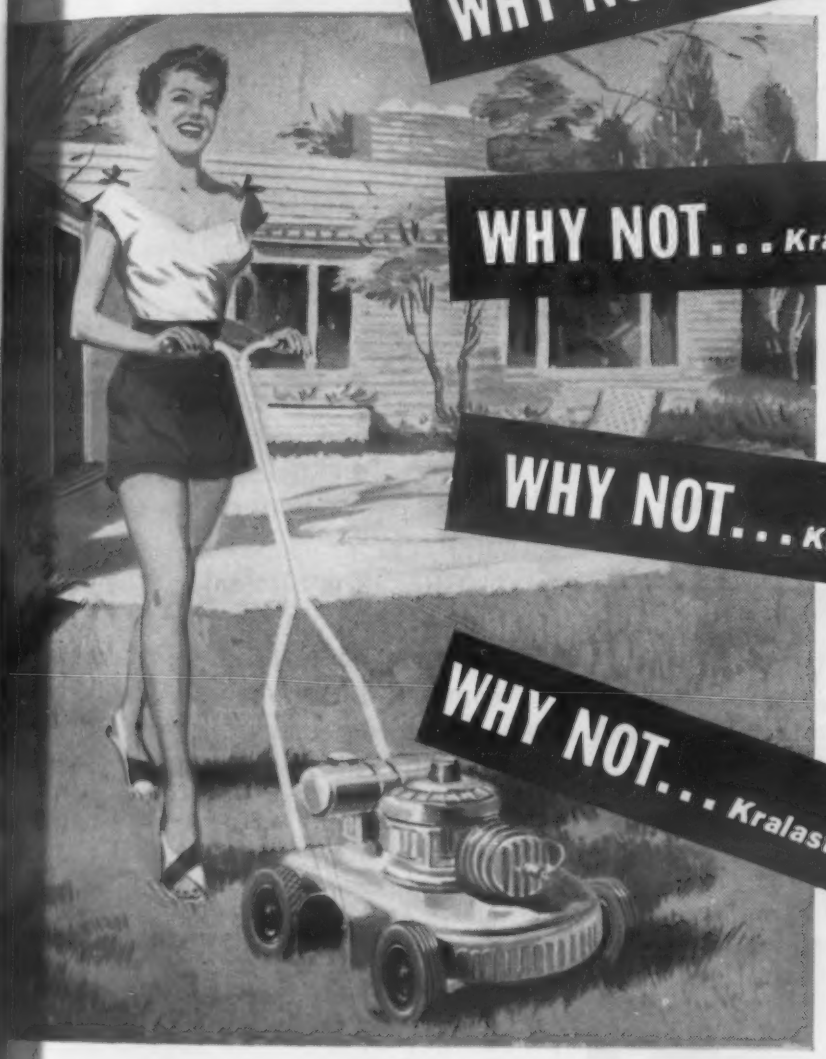
For more information, Circle No. 409 ➤

## HERE'S WHY KRALASTIC WHEELS are now used for Power Lawn Mowers

Kralastic® wheels are...

- rustproof—non-corroding
- self-lubricating—quiet-running
- highly resistant to abrasion and impact
- lighter than aluminum
- attractively, permanently colored
- easily assembled—relatively inexpensive

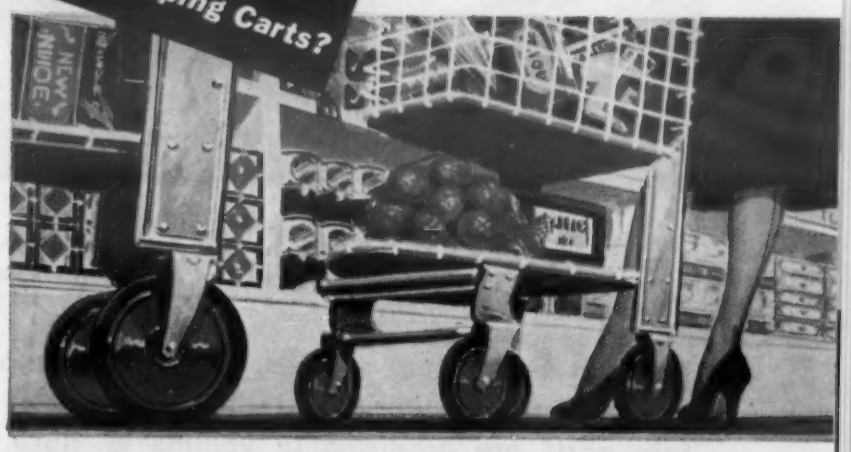
**WHY NOT... Kralastic Pulleys and Rollers?**



**WHY NOT... Kralastic Wheels for Lawn Furniture?**

**WHY NOT... Kralastic Wheels for Kiddie Carts?**

**WHY NOT... Kralastic Wheels for Shopping Carts?**



...are but a few of dozens of exciting possibilities this unusual rubber-resin plastic offers in wheel goods alone. With unique combination of hardness *and* toughness—its great resistance to abrasion, weather, and most chemicals—high dimensional stability—and reliable performance over a wide temperature range—Kralastic has already brought new profits to *hundreds* of manufacturers.

*Why not consider the many opportunities* for improved product performance Kralastic offers *you?* For further information, simply write on your letterhead to the address at right.

**Naugatuck Chemical**

Division of United States Rubber Company
Naugatuck, Connecticut

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N.Y.

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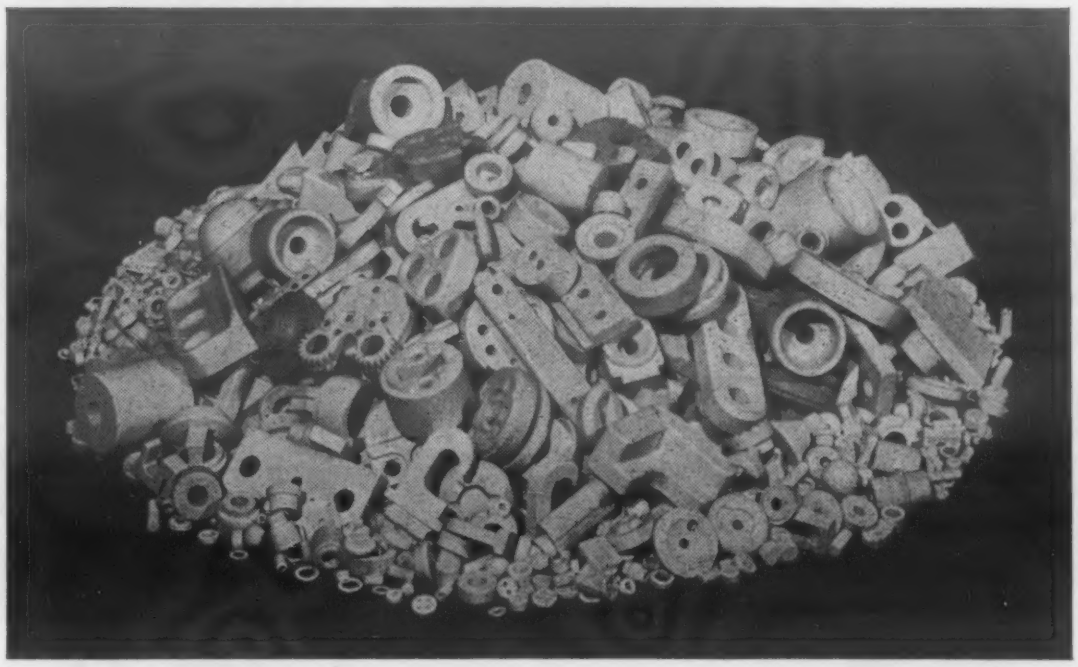
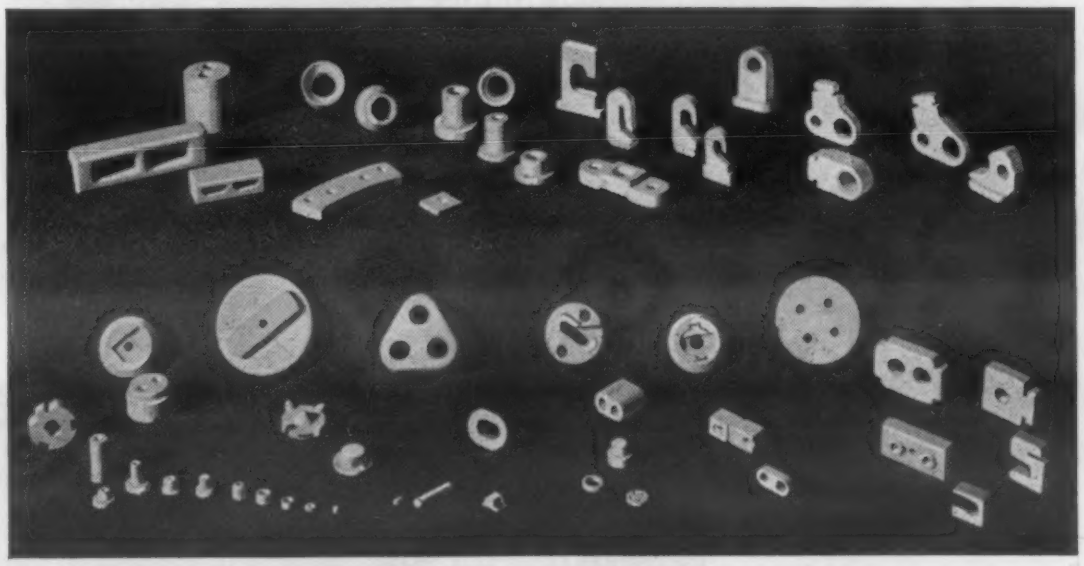
# STAR LAVOLAIN®

## Parts by the Million . . .



## in all Manner of Shapes



## to your Specifications

**Resistance-wire hooks, rods, bushings, lampsocket buttons, ferrules, switch bases, insulating beads—all types of small LAVOLAIN porcelain parts are produced in volume to close tolerances on automatic machinery to reduce your costs and help maintain your production schedules. LAVOLAIN, highly resistant to thermal shock, is used in many types of heating devices. It has high dielectric and mechanical strength and does not absorb moisture.**

***Name your problem. We'll be glad to work with your engineers, Samples sent on request.***

Star PORCELAIN COMPANY

39 Muirhead Avenue • Trenton 9, N. J.

For more information, turn to Reader Service Card, Circle No. 337


# New Materials, Parts, Finishes

*& Dye Corp.*, 40 Rector St., New York 6. Called BRC 22 Hydrocarbon, the material is said to confer no appreciable amount of tack to the raw compounds, thereby simplifying processing, particularly with neoprene elastomers. It is also said to minimize shrinkage and improve the flow of the compound during curing of molded products.

According to the manufacturer, the material provides high tear resistance particularly at elevated temperatures, and when used with extruded compounds, lends reinforcing and stiffening characteristics. This results in resistance to sagging and flattening during extrusion and curing.

BRC 22 is also said to be useful in reclaiming rubber. The addition of 3 to 5% of the new compound improves processibility and decreases the percentage of tailings without adversely affecting physical properties of the finished product.

## New Industrial Tapes: Pressure Sensitive, Teflon, Glass, Insulation

Several new industrial tapes have been marketed for a variety of applications: two pressure sensitive cloth tapes for packaging, a pressure sensitive tape made of DuPont's Teflon for chemical protection, a new line of all-purpose glass cloth tapes, and a filler tape for insulating.

### Cloth tapes

Two pressure-sensitive printable Cotton Cloth Tapes designed to meet the requirements of JAN-P-127, Tape II, Grade B have been marketed by the *Permacel Tape Corp.*, New Brunswick, N. J. They are said to be adaptable for bundling parts, wires, cables, tubing and other

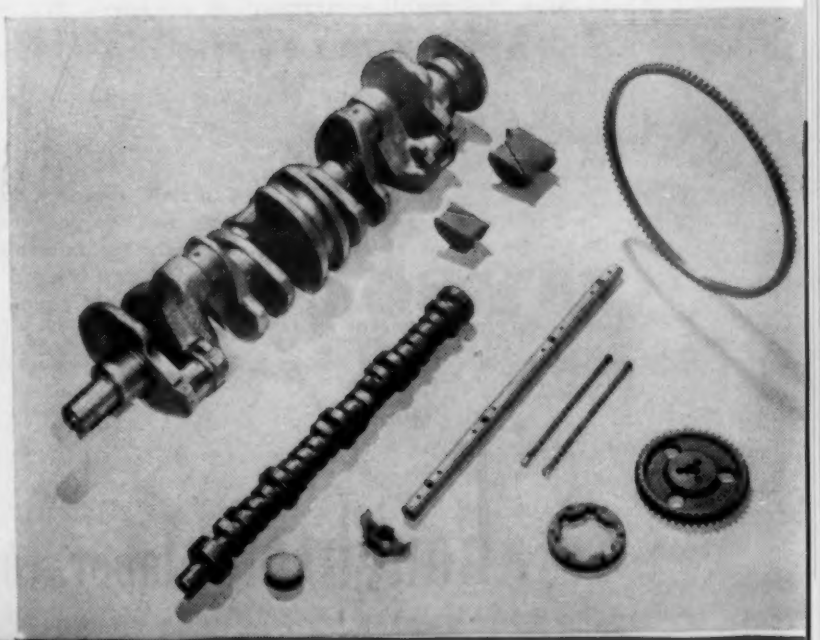
# what's new?

NO. 28 OF A SERIES.

## flamatic hardens crankshaft bearings

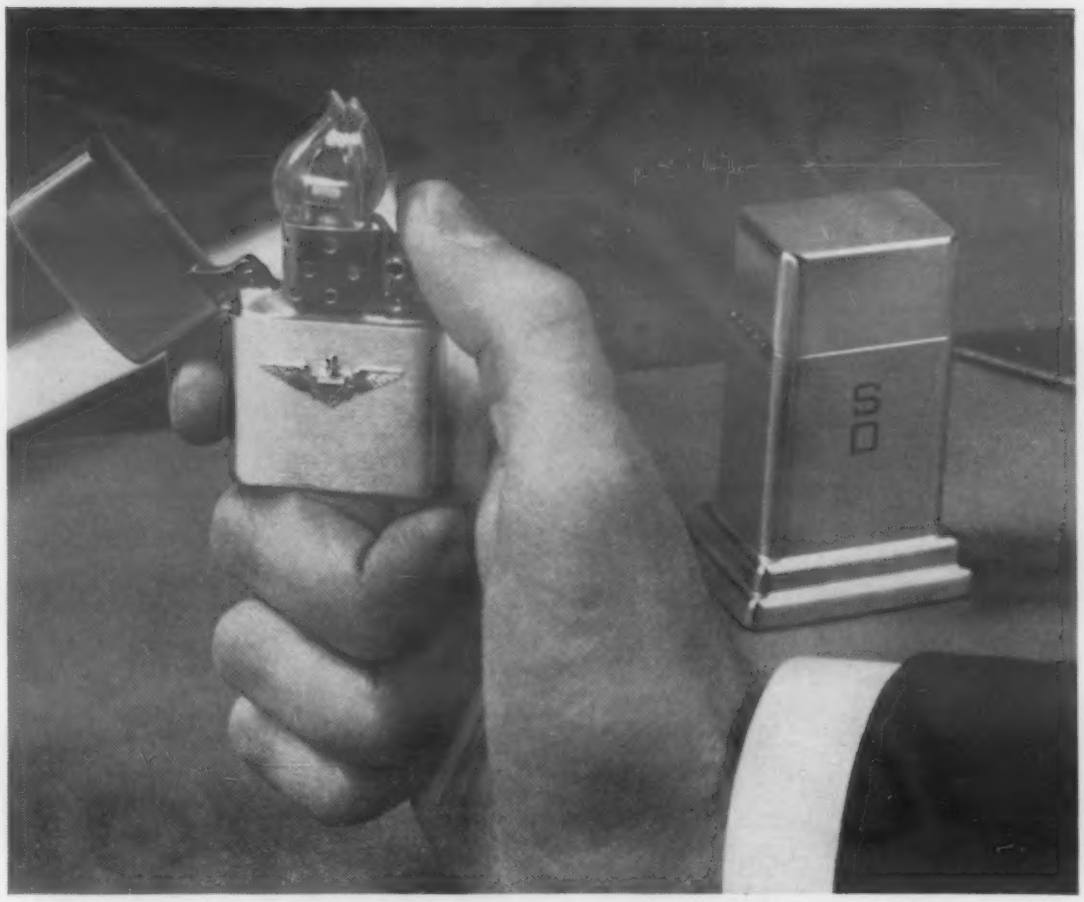
## 10/hr. to 70/hr.

It's no wonder the automotive industry turns to **flamatic** for selective heating precision. This machine, for example, provides the flexibility for development work on a variety of crankshafts or small lot production up to 10 parts/hour, simultaneously hardens main and pin bearing diameters in one operation. Interchangeable flame heads, adjustable flame head holders, and movable tailstock permit quick changes from one size to another . . . Another **flamatic** hardening machine for one size crankshaft hardens 70 parts/hour. Single- or multi-purpose **flamatic** machines have met production requirements on many automotive parts, a number of which are shown at the right. Write for new **flamatic** catalog, Publication No. M-1861.



CINCINNATI **flamatic**

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.
For more information, Circle No. 472



# HYSOL ADHESIVES bonds metal-to-metal . . . provides sealant in ZIPPO LIGHTERS

Conclusive tests have proven that HYSOL Adhesives can meet the most exacting industrial bonding requirements of metal, glass, laminates, ceramics, wood and synthetics. Years of experience in industrial research have developed HYSOL adhesives with outstanding resistance to temperature variations, chemical or electrical attack, with no cracking, chipping or loss of any of its other properties.

HYSOL adhesives more than satisfied ZIPPO requirements for a material with a two-fold purpose; to bond metal-to-metal and to act as a sealant. If you have a special problem in industrial adhesives, Houghton Laboratories is ready to serve you. The ZIPPO and many other varied applications of HYSOL industrial adhesives now in use provide excellent experience in helping solve your problem.

PROGRESSIVE PRODUCTS THRU CHEMICAL RESEARCH
HYSOL
Products of HOUGHTON LABORATORIES, INC.

Complete research facilities and an experienced staff will go to work immediately, giving you precisely the industrial adhesive you need, compounded and colored to your exact specifications. Write, wire or phone today . . . there is no obligation.

houghton laboratories, inc.

130 BUSH STREET, OLEAN, NEW YORK

For more information, turn to Reader Service Card, Circle No. 374


# New Materials, Parts, Finishes

materials used for storage, marketing or inter-plant use. Called Permacel 641 Production Grade and Permacel 651 Medium Strength Sized Cotton Cloth Tapes, they are said to have an average adhesive strength of 45 oz per in., a 10% elongation, and to be 14 mil thick. P 641 has a tensile strength of 37 lb per in., while the P 651 has a 50-lb per in. tensile strength.

According to the manufacturer, they can be used for holding rivets prior to driving, holding insulation on pipe lines and protecting finished surfaces against abrasion or corrosion in shipment or during manufacture.

**Teflon tape**

A pressure sensitive tape consisting of a 1 mil silicone adhesive coating on a 5 mil film of DuPont's polytetrafluoroethylene resin has been marketed by *Minnesota Mining and Mfg. Co.*, 900 Fauquier St., St. Paul 6, Minn., under the trade name Scotch brand No. 549. The semi-transparent, blue-gray tape is designed for application to a variety of surfaces as a protective covering material. Applied to a small roller, for instance, it provides corrosion protection combined with anti-sticking properties. The tape features a tensile strength of 15 lb per in. and elongation of 300%, according to the manufacturer. It is unaffected by temperature change within the range of —65 to 350 F, and withstands 7-day immersion in 1) distilled water, 2) 3% sulfuric acid, 3) 30% sulfuric acid, 4) 10% sodium

# ALSIMAG®

Widest selection of latest materials. Constant addition of new special-purpose bodies. Over 50 years accumulated experience and "know how." A highly trained staff, alert for improvements and new techniques.

## low . . .

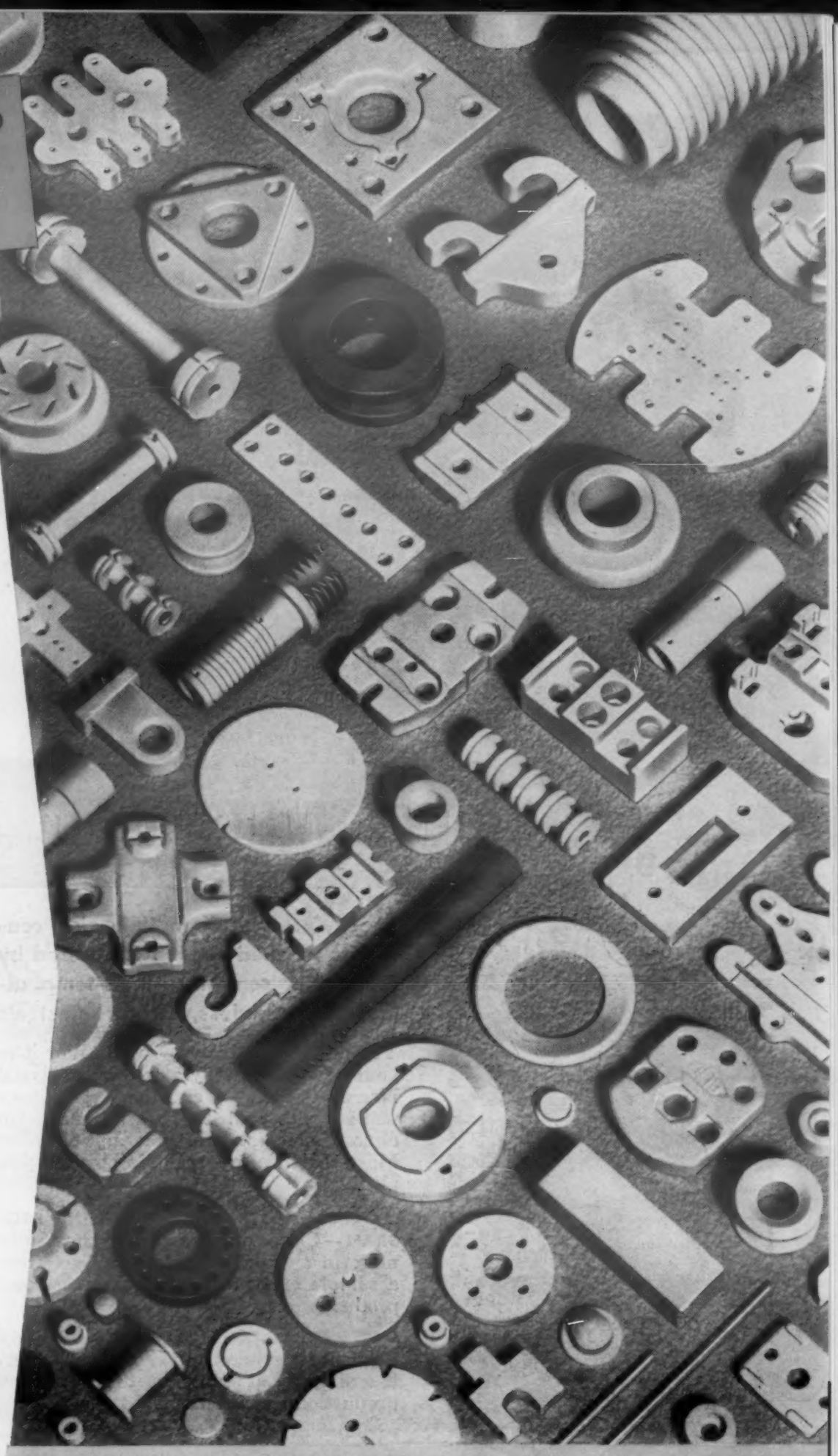
True cost is what you get for what you pay. It's risky to buy ceramics by price alone. It may mean mediocre material and outdated design. You'll profit by investigating the recent "giant steps" taken in the ceramic field.

## cost . . .

AlSiMag offers the best possible ceramic for your job at a price that's right. Modern, large-scale equipment cuts production costs. Shipments are on time and to specification. AlSiMag extra services include free redesign service and use of open dies.

## ceramics

Assembly lines run on deliveries, not promises. That's why we're careful to make delivery estimates that are dependable. True, ceramics are temperamental. But you'll find AlSiMag's "shipment as promised" average is high. Ask any of our customers.



• Send a blueprint and outline of operating conditions and see what American Lava can do to save you money.

53RD YEAR OF CERAMIC LEADERSHIP

**AMERICAN LAVA CORPORATION**

A SUBSIDIARY OF MINNESOTA MINING AND MANUFACTURING COMPANY

**CHATTANOOGA 5, TENNESSEE**

**Branch offices in these cities (see your local telephone directory):**
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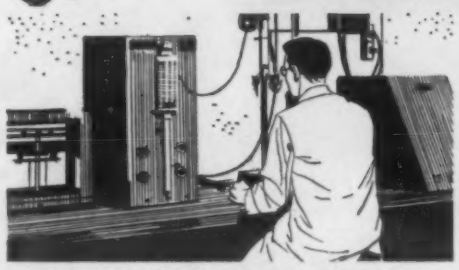
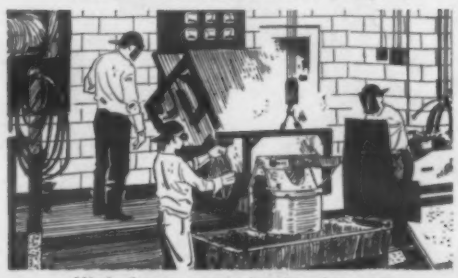
# Need pounds or tons of

# Custom-made Alloys for remelt or reprocessing?

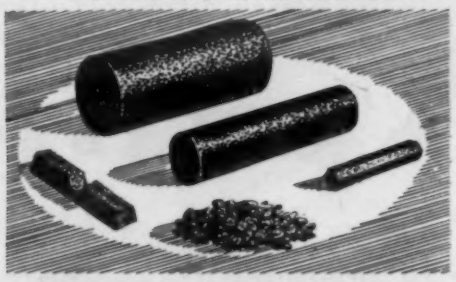
## Call on Cannon-Muskegon



Heats checked for chemical analysis.



High frequency induction furnaces.



Carried in stock are supplies of the 300 and 400 stainless steels as well as carbon alloys. "Specials" including electronic and aeronautical type alloys, tool steels, ferritic, austenitic and super stainless alloys of nickel- and cobalt-base. Available in shot, ingot, billet or cast bars.

**Exactly predictable metallurgical control of finished casting is assured by MasterMet control of high-temp alloys, tool, stainless, and carbon steels**

You specify the alloy — we'll tailor it to your needs, backed by a *certified* analysis! Name the quantity and the fast delivery will surprise you! Preparation can begin almost immediately after receipt of order. MasterMet "alloy tailoring" gives you all this:

**MATCHED ALLOYS TO YOUR MELTING PROGRAM**—Close control assures a constantly uniform melt. The results you get from a sample cast are the same as the final production run.

**MASTERMET CERTIFIED ANALYSIS**—Regularly furnished are notarized certificates insuring alloys that will cast to your exact production specifications.

**PRODUCTION MELTS OR SAMPLE JOBS** — A combination of test furnaces and larger multiple production furnaces assure completely flexible service at any time.

**FAST ACTION ON YOUR ORDERS** — No long delays for a mill run. Alloys delivered in drums, clearly marked with all specifications for fast selection and storage.

Write today for your copy of new MasterMet Alloy Bulletin for complete technical details.

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MASTERMET
2873 Lincoln Street • Muskegon, Michigan

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service Card, Circle No. 309


# New Materials, Parts, Finishes

chloride, and 5) 1% sodium hydroxide. The tape is available in ½ to 5-in. widths on 36-yd rolls.

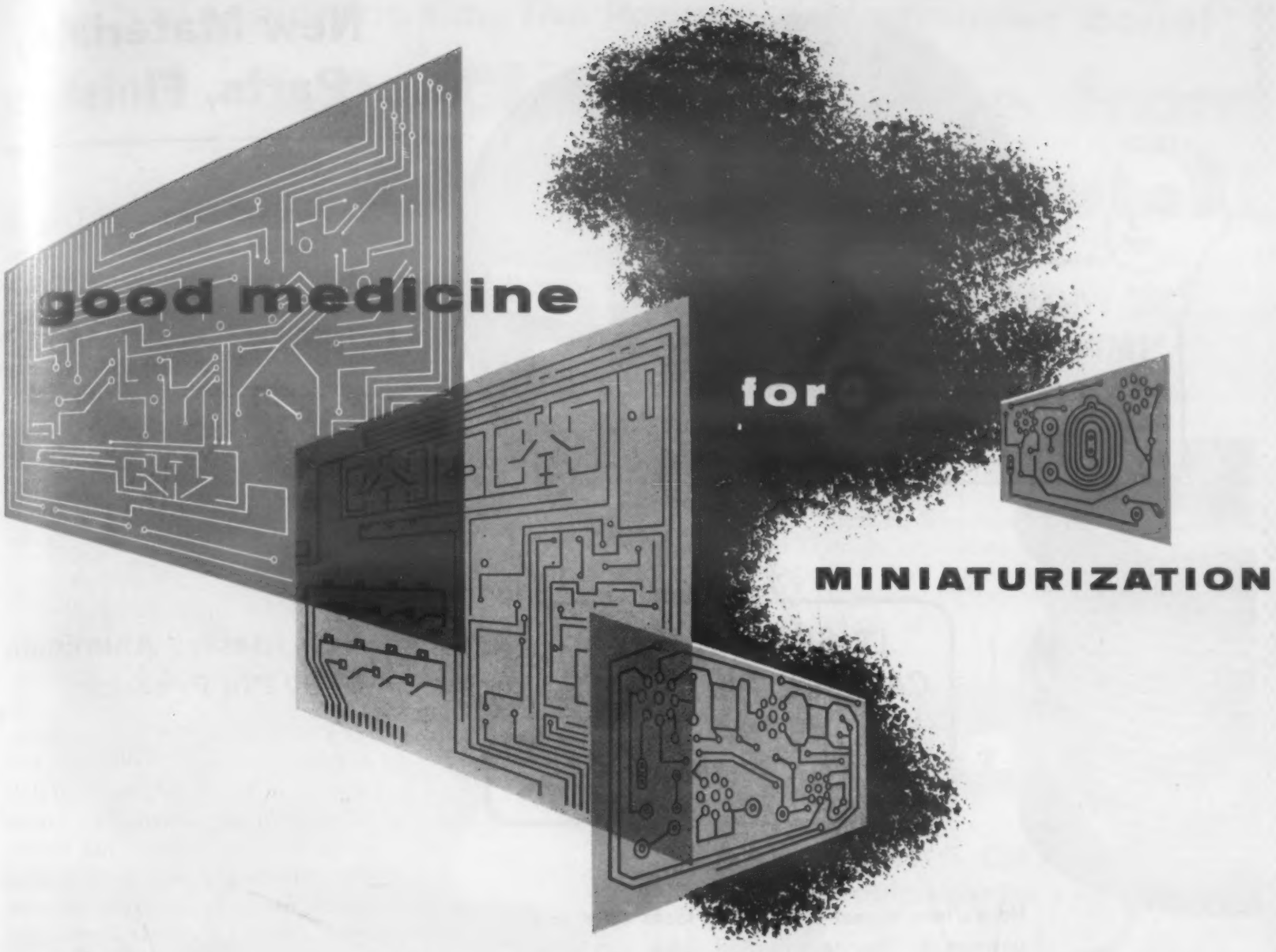
### Woven glass tapes

A new line of all-purpose glass tapes, said to be less expensive than similar tapes now on the market, has been developed by the *Horace Linton Div., Hess, Goldsmith & Co., Inc.*, 1400 Broadway, New York. The new tapes are said to make full use of the high tensile strength, good heat conductivity, low moisture absorption and high resistance to most acids and alkalis inherent in glass.

Called the Hesgon series, the tapes are suitable for wrappings for field coils, armature coils and stator coils in d.c. motors and generators, and in a.c. induction motors, and synchronous motors and generators. The tapes are available in standard widths from ½ to 1-½ in. and in thicknesses from 0.004 to 0.015 in. They are woven in medium, Hesgon-A, and close, Hesgon-B, weaves.

### Tape form insulation

A new insulating compound in tape form has been marketed by *Bishop Mfg. Co.*, 112 Factory St., Cedar Grove, N. J., under the trade name of Bishop No. 125 Electrical Filler Tape. The tape is wound together with a fabric separating strip in the form of a roll, and is intended to replace bulk insulating fillers which require troweling. Areas to be built up can be thumb-molded to shape and pressed on




By their very nature, *printed circuits* are extremely compact. They open up virtually unlimited possibilities to alert designers concerned with the miniaturization of electrical and electronic devices. From the simplest switches to the most complex computers, printed circuits are proving their versatility and great potential application.

Complicated manual wiring is replaced by a pattern of conductors, coils, resistors, and other components "printed" on a sheet of laminated plastic. Low in cost, uniform in performance, and free of wiring "bugs," such assemblies are speedily mass-produced. Labor costs are drastically cut two ways—far fewer personnel are needed, and lesser-skilled workers can easily assemble (and service) complex devices with less chance of error. Since exact wiring duplication is achieved, inspection is greatly simplified. Assemblies grow small in size, overhead is reduced, less floor space is needed . . . the whole problem takes a big "easy-does-it" step toward complete automation.

National Vulcanized Fibre Co. is a pace-setter in the development of foil-clad laminates—the basic materials for most printed circuitry. Copper-Clad Phenolite—by National—is recognized as the standard by fabricators everywhere. For Phenolite is a high-quality base laminate that can be *engineered* to fit *your* conditions. It has the high insulation resistance, low electrical loss, and low moisture absorption required in the *right* base material for printed circuits. It is light in weight, easily punched and worked, and withstands effects of the various circuit-printing processes.

No matter which method you use to produce printed circuits, Phenolite clad laminates are the ideal base materials. Whether clad with metal foils, or non-metallic materials (such as rubber, vulcanized fibre, etc.) there is a Phenolite laminate for *your* particular job.

Ask any of our district offices or Wilmington headquarters for details.

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Laminated PLASTIC

***HERE'S HELP FOR YOU**—our new, fact-filled, 12-page bulletin entitled "Mechanize Your Wiring With Copper-Clad Phenolite." Contains full information and application data on Copper-Clad Phenolite and other metal and non-metal clads. Write for it today! Address Dept. D-1.*

*Also manufacturers of Vulcanized Fibre, Vul-Cot Waste Baskets, Peerless Insulation, Materials Handling Equipment and Textile Bobbins*

**NATIONAL**
**VULCANIZED FIBRE CO.**
WILMINGTON 99, DELAWARE

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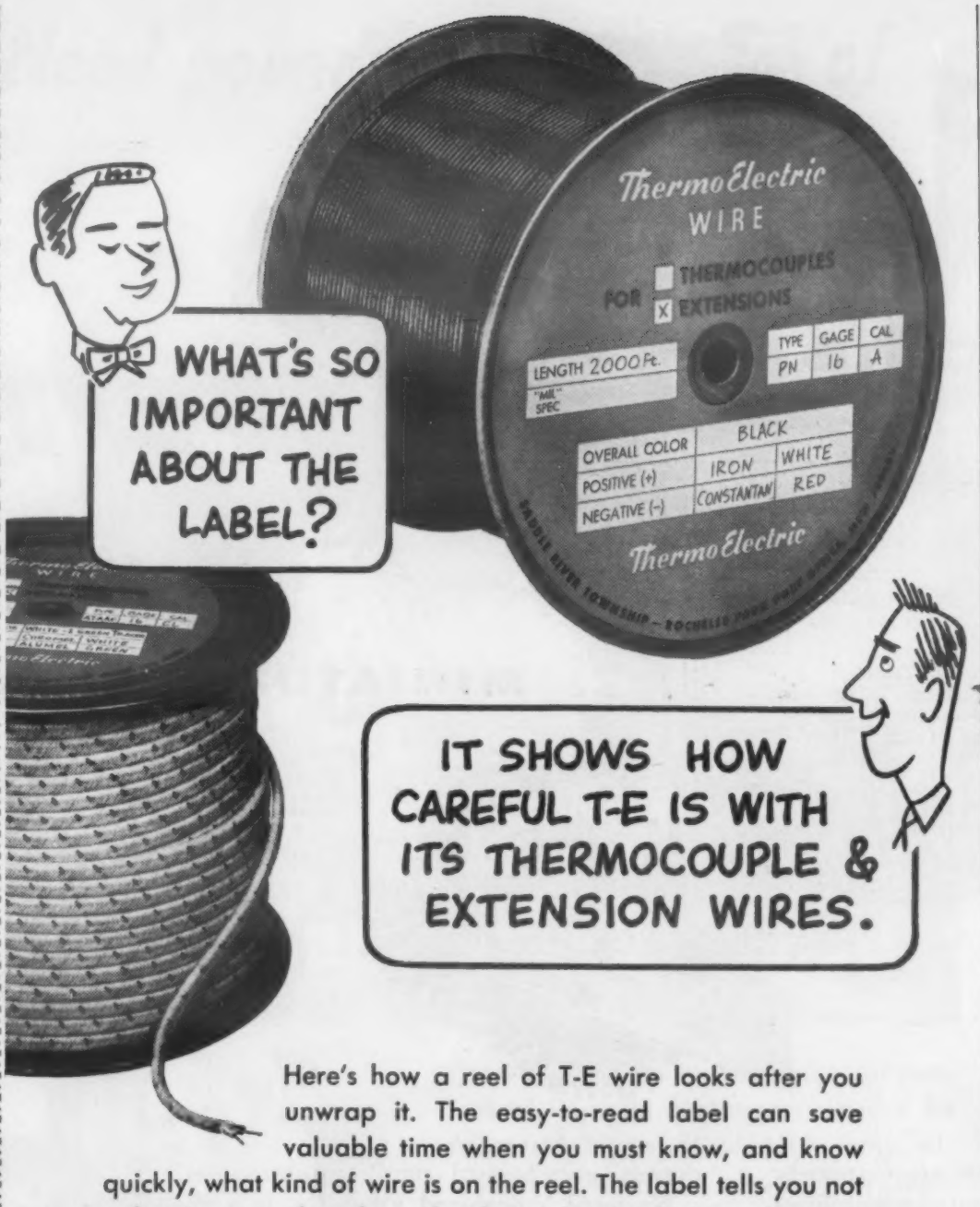
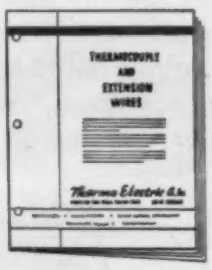

WHAT'S SO IMPORTANT ABOUT THE LABEL?
IT SHOWS HOW CAREFUL T-E IS WITH ITS THERMOCOUPLE & EXTENSION WIRES.
Thermo Electric
WIRE
FOR THERMOCOUPLES
X EXTENSIONS
LENGTH 2000 Ft.
"MIL" SPEC
TYPE | GAGE | CAL
PN | 16 | A
OVERALL COLOR | BLACK
POSITIVE (+) | IRON | WHITE
NEGATIVE (-) | CONSTANTAN | RED
Thermo Electric

Here's how a reel of T-E wire looks after you unwrap it. The easy-to-read label can save valuable time when you must know, and know quickly, what kind of wire is on the reel. The label tells you not only wire type, length, and polarity, but insulation colors too. Therefore, you can identify conductors easily by comparing colors listed on the label with those on the wire itself.

As you can see, it's a well-thought-out label. Important by itself, it's also a revealing illustration of the care T-E takes. Thoroughness is characteristic of every step in T-E's wire production, from drawing and calibrating to insulating. The result of such care is a product which meets high industrial standards.




There are too many T-E wires to mention comfortably in one ad. However, in T-E's 8-pg. Wire Bulletin you can see insulations, gages, and calibrations, as well as charts with calibration symbols, color codes, insulation characteristics, resistances, weights, electrical properties, and conduit capacities. Write for Bulletin 31-G.

**Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors**
**Thermocouple and Extension Wires • Resistance Bulbs • Connector Panels**

**Thermo Electric Co., Inc.**
**SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY**
**IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO**

**For more information, turn to Reader Service Card, Circle No. 339**


# New Materials, Parts, Finishes

as required. The material is said to fuse to a homogeneous mass in seconds. In addition to its primary use for build-up of cable-splice insulation, it is said to be suitable for covering sharp-cornered electrical connections and padding the edges of bus bars. The compound should then be covered with a plastic electrical tape. The Filler Tape is available 1-½ in. wide and ⅛ in. thick.

## New Master Aluminum Alloy Pig Products

Two new master alloys, designated 2364 and 2939, are now available from *Reynolds Metals Co.*, 2500 S. Third St., Louisville, Ky., at regular pig prices. The alloys are said to provide a more uniform analysis by simple blending with secondary metals to control undesirable impurities.

The 2364 alloy pig has a controlled analysis of 6 silicon, 4% copper, nominal iron, and balance aluminum. The 2393 alloy has a controlled analysis of 9 silicon, 3.5 copper, 0.75% iron and balance aluminum. The alloys are available in 50-lb pigs.

## Coloring System For Plastics

A newly developed series of color paste concentrates has been marketed for coloring epoxy, Thiokol and polyurethane resin systems. Designated the 4000 Series by their producers, *Claremont Pigment Dispersion Corp.*, 110 Wallabout St., Brooklyn 11, N. Y., each paste is said to be smooth and free flowing, permitting rapid, uniform coloring of the liquid resin by stirring. The colors are said to possess good stability when exposed to heat, light, various catalysts and the resins themselves.

*(More New Materials on page 166)*

**For more information, Circle No. 468**

## At Janks Sandblasting Co., The Pangborn Blastmaster® Barrel

# Cuts Cleaning Time from 1¼ Hours to 3 Minutes!

The Janks Sandblasting Company, Syracuse, N. Y., is a commercial blast cleaning firm handling ferrous and non-ferrous work. Recently the installation of a Pangborn Blastmaster Barrel, in a special below floor-level pit, has enabled Owner Bob Janks to lower his operating costs and charge his customers much less. How so? Certain typical items used to require an hour and 15 minutes to clean. Today the Blastmaster cleans them in *3 minutes* and gives a fine finish! No wonder Mr. Janks calls the Blastmaster "an excellent machine"!

Do *you* want a *better* finish . . . in *less* time . . . at *lower* cost? Then investigate the Pangborn Blastmaster Barrel, available in 1½, 3, 6, 12, 18 and 27 cu. ft. capacities. The letter that takes a minute to write may save you hundreds of dollars a year! Write for Bulletin 225: PANGBORN CORPORATION, 1700 Pangborn Boulevard, Hagerstown, Md.

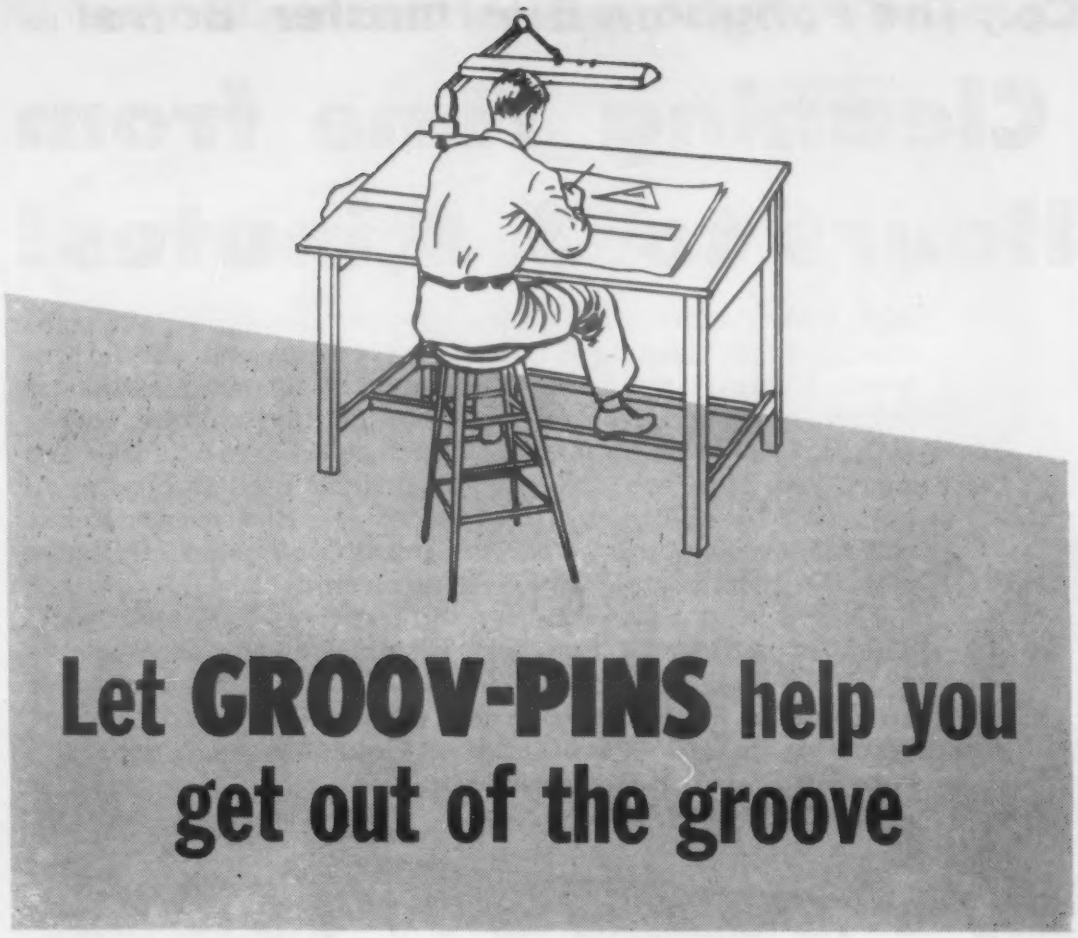
**Pangborn**

*Look to Pangborn for the latest developments in Blast Cleaning and Dust Control Equipment.*

**BLAST CLEANS CHEAPER**
**with the right equipment for every job**

*U. S. Patent # 2184926 (other patents pending)

ses Malleabrasive *
master for even
peration.



# Let GROOV-PINS help you get out of the groove

It is easy to get into a groove in product design and redesign. This is particularly true where fasteners are concerned. With some design engineers it is threaded fasteners or nothing. The possibilities for decreasing the cost and increasing the usefulness of their products through the use of pin fasteners, where applicable, are ignored.

By contrast, many of the best-designed products in the country incorporate Groov-Pins in their construction. A large number of prominent American manufacturers have used Groov-Pins for a quarter century or more with substantial savings in manufacturing and maintenance costs, simplification of design, and customer satisfaction.

*Typical Groov-Pin Forms*

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# Contents Noted

*A digest of papers, articles, reports and books of current interest to those in the materials field.*

**This Month:**

- *Electrical properties of plastics*
- *Spotting MS points in steel*
- *Plastics films for packaging*
- *Zirconium at high temperatures*

## Dielectric Strength and Endurance of Thermosetting Laminates

Thermosetting laminates are used for electrical insulation because they combine high dielectric strength with mechanical strength, low weight and ease of fabrication. They also resist chemical corrosion, moisture, aging, heat and temperature deterioration. In selecting the material to be used, the designer is primarily concerned with insulation resistance, dielectric loss and dielectric breakdown.

In a paper presented at the June, 1954, Semi-Annual Meeting of the American Society of Mechanical Engineers, N. A. Skow, of the Synthane Corp., described tests for endurance limits of dielectric strength run on several grades of thermosetting plastics laminates, plotting voltages against time. Tests were conducted both parallel and perpendicular to lamination since substantial differences exist in dielectric breakdown properties of the laminates when stressed in these directions. The difference indicates that the same dielectric strength and endurance do not exist where the sheets are used as insulating spacers (stressed perpendicular to lamination) and as terminal-board insulators (stressed parallel to lamination).

### Seven grades tested

Seven standard NEMA grades were tested: Grades X, XX, XXXP, LE, A, G-5 and N-1. These grades were selected as representative of the NEMA group. Grades X, XX and XXXP are paper-base laminates bonded with phenolic resin. Grade X is intended primarily for mechanical applications and should be used with discretion under high-humidity conditions. Grade XX, though slightly weaker mechanically, is better electrically and is made with a more absorbent paper with a higher resin content. Grade XXXP, which has still higher resin content, is one of the best electrical laminates produced.

Grade LE has a cotton-fabric base bonded with phenolic resin. It is used for electrical applications requiring greater tough-

*(Continued on page 168)*

**Table 1—Effect of Temperature on Dielectric Strength (Short Time) of Laminates**

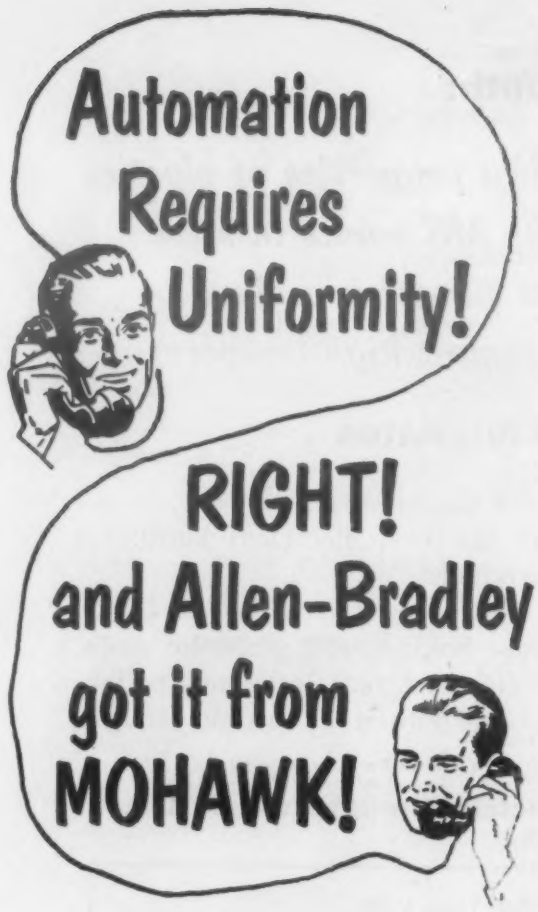
| Temp, F | Dielectric Str (Short Time) V/Mil | | | | | |
|---|---|---|---|---|---|---|
| | Grade XX | | Grade XXXP | | Grade N-1 | |
| | Perpendicular[a] | Parallel[b] | Perpendicular[a] | Parallel[b] | Perpendicular[a] | Parallel[b] |
| 65 | 700 | 154 | 900 | 160 | 520 | 240 |
| 100 | 339 | 158 | 800 | 158 | 483 | 220 |
| 170 | 160 | 140 | 750 | 146 | 317 | 140 |
| 202 | 120 | 128 | 719 | 150 | 213 | 104 |
| 210 | 103 | 120 | 675 | 140 | 170 | 92 |
| 244 | 86 | 104 | — | 129 | 140 | 52 |
| 256 | 82 | — | — | 148 | 134 | — |

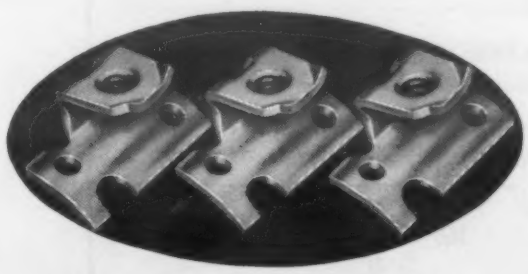
[a] *Average for five specimens conditioned for 1 hr at 220 F.*
[b] *Average for five specimens conditioned for 8 hr at 220 F.*

**Table 2—Effect of Sample Thickness on Dielectric Strength (Short Time) of Laminates: Tested Dry at 73 F**

| Thickness, In. | Dielectric Str (Short Time) V/Mil | | |
|---|---|---|---|
| | Perpendicular to Laminations[a] | Parallel to Laminations[b] | |
| | Grade XX Paper-Base | Grade X Paper-Base | Grade XX Paper-Base |
| 1/32 | 940 | — | — |
| 1/16 | 695 | 360 | 530 |
| 1/8 | 515 | 270 | 275 |
| 1/4 | — | 160 | 180 |
| 3/8 | — | 120 | 130 |
| 1/2 | — | 110 | 120 |

[a] *Average for five specimens, conditioned for 1 hr at 220 F.*
[b] *Average for five specimens, conditioned for 8 hr at 220 F.*



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ness than provided by Grade XX. Grade A, an asbestos paper-base bonded with phenolic, is more flame and heat resistant than the cellulosic grades. Grade G-5 is a glass-base laminate, bonded with melamine resin, with high mechanical strength, excellent electrical properties under dry conditions and good heat, flame and arc resistance. Grade N-1 is a nylon-fabric base bonded with phenolic resin. It has high electrical and mechanical properties even under high humidity conditions.

**Results of tests**

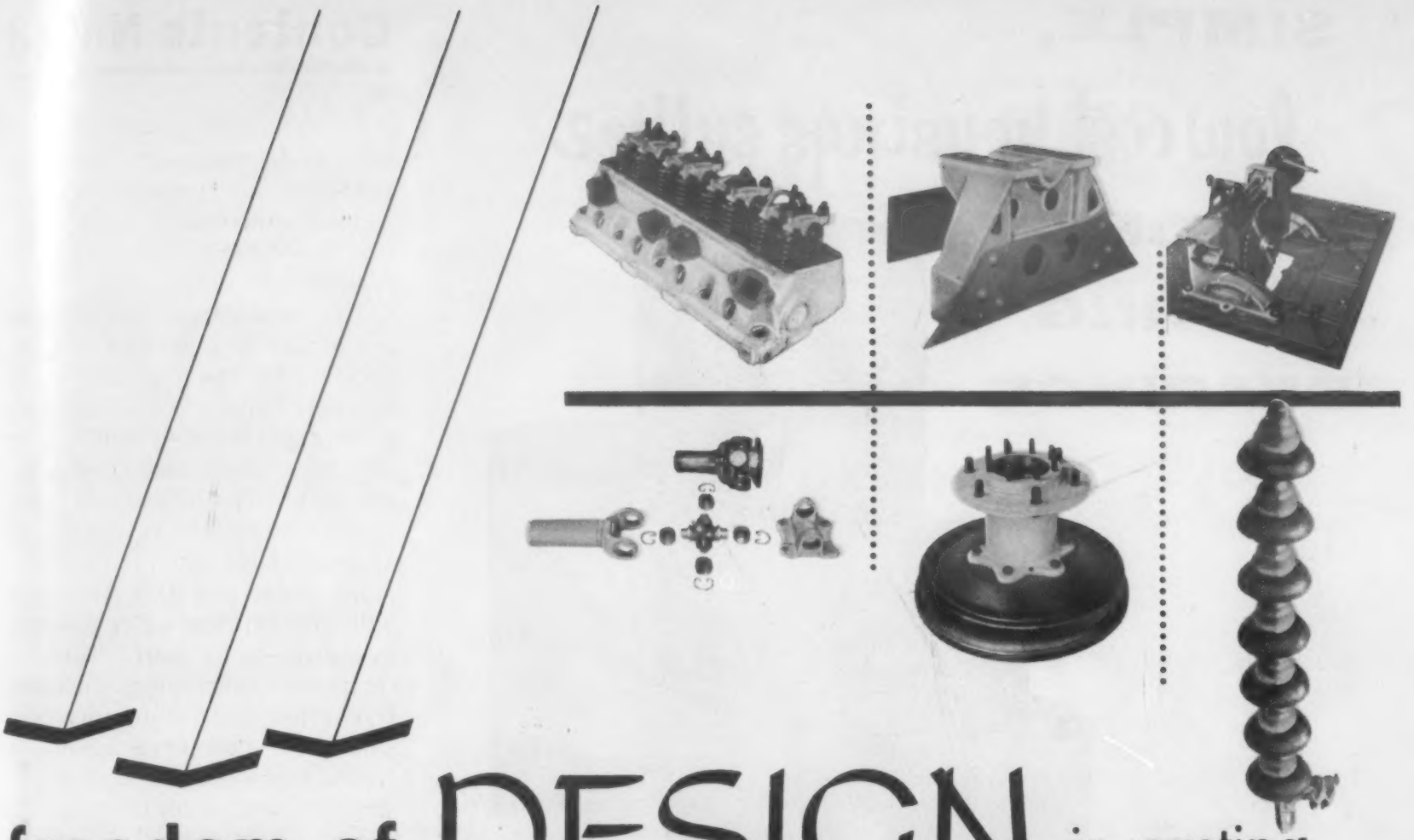
A glance at Table 1, showing dielectric strength vs temperature, reveals two significant facts regarding the Grades XX, XXXP and N-1. That is that short-time dielectric strengths parallel to laminations are usually lower than those perpendicular, and the difference in dielectric strength vs temperature characteristics parallel to laminations is comparatively small.

Grade XXXP has the highest dielectric strength perpendicular to laminations within the 65-256 F temperature range tested; and the drop in breakdown voltages is very small between 100 and 200 F. Above this temperature there is a rapid decrease in breakdown voltage. The breakdown characteristics of the three grades parallel to laminations are more nearly equal.

The effect of sample thickness on short-time dielectric strength of laminates is indicated by Table 2. As can be seen, the volts per mil decrease in dielectric strength may be compared with the law of diminishing

**TABLE 3—SHORT-TIME DIELECTRIC STRENGTHS AND ENDURANCE LIMITS OF LAMINATES TESTED AT 73 F**

| | GRADE | THICKNESS CONDITIONING | Short Time Diel Str v/mil | Endurance Limits v/mil | Endurance Limits Short Time Diel Str, % |
|---|---|---|---|---|---|
| | | | PERPENDICULAR TO LAMINATIONS | | |
| A | X | 1/16 in. Thick, Dry | 649 | 320 | 49.3 |
| A | XX | 1/16 in. Thick, Dry | 695 | 390 | 56.1 |
| A | XXXP | 1/16 in. Thick, Dry | 780 | 500 | 64.2 |
| A | LE | 1/16 in. Thick, Dry | 434 | 320 | 73.8 |
| A | A | 1/16 in. Thick, Dry | 155 | 130 | 83.8 |
| A | G-5 | 1/16 in. Thick, Dry | 450 | 310 | 68.9 |
| A | N-1 | 1/16 in. Thick, Dry | 394 | 305 | 77.4 |
| B | XX | 1/16 in., 96 hr at 90% RH 95 F | 240 | 150 | 62.5 |
| B | XX | 1/16 in., 48 hr in $H_2O$ at 122 F | 112 | 55 | 49.5 |
| C | XXXP | 1/16 in., 96 hr at 90% RH 95 F | 700 | 400 | 64.2 |
| C | XXXP | 1/16 in., 48 hr in $H_2O$ at 122 F | 680 | 375 | 57.2 |
| | | | PARALLEL TO LAMINATIONS | | |
| | X | 1/4 in. Thick, Dry | 124 | 92 | 74.2 |
| | XX | 1/4 in. Thick, Dry | 176 | 108 | 61.3 |
| | XXXP | 1/4 in. Thick, Dry | 172 | 124 | 72.0 |
| | LE | 1/4 in. Thick, Dry | 206 | 134 | 65.0 |
| | A | 1/4 in. Thick, Dry | 48 | 36 | 75.0 |
| | G-5 | 1/4 in. Thick, Dry | 144 | 100 | 69.4 |
| | N-1 | 1/4 in. Thick, Dry | 240 | 180 | 75.0 |
| | XX | 1/4 in., 21 days at 90% RH, 50 C | 100 | 80 | 80.0 |
| | XX | 1/4 in., 21 days in $H_2O$ at 50 C | 38 | 18 | 47.4 |
| | XXXP | 1/4 in., 21 days at 90% RH, 50 C | 112 | 96 | 85.7 |
| | XXXP | 1/4 in., 21 days in $H_2O$ at 50 C | 56 | 28 | 50.0 |



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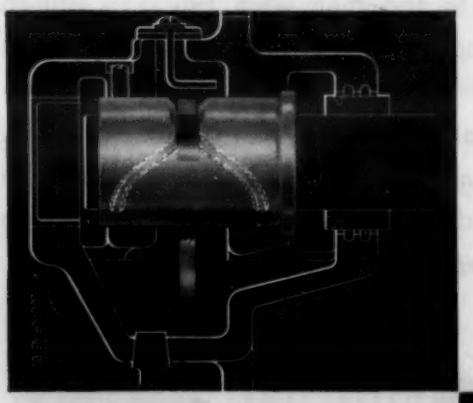

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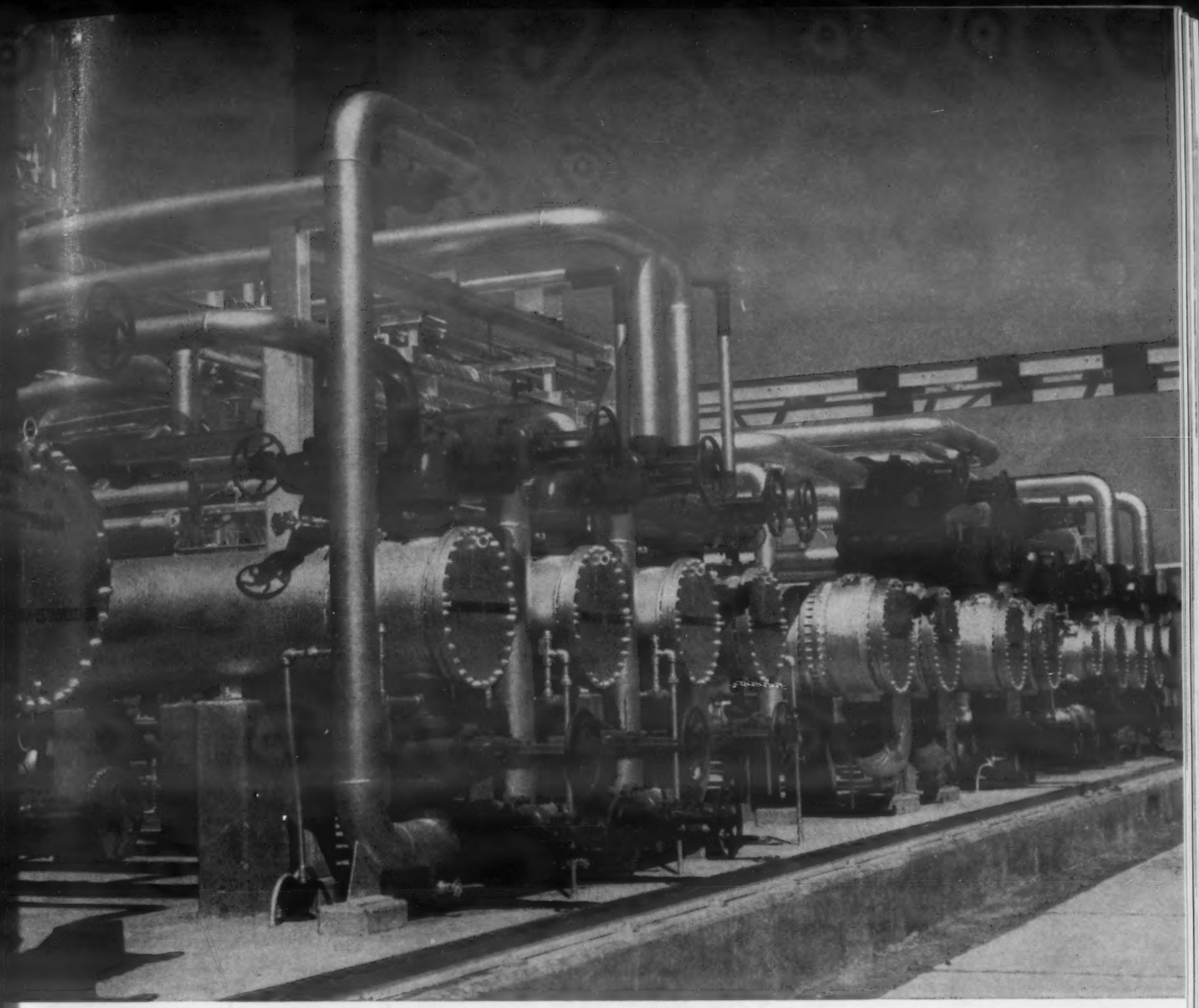
## Contents Noted

returns in that each additional thickness of laminate provides a smaller increase in total dielectric breakdown voltage of the sample.

The endurance limits, perpendicular and parallel to laminations, for the 7 grades tested decrease rapidly with time until it is approximately 60 to 70% of the short-time dielectric strength. The endurance limit of the materials is considered approximately equal to the maximum dielectric strength which will not rupture after 100-min exposure to stress. Table 3 compares short-time dielectric strengths and endurance-limit values for the seven laminates. Grade A has the lowest dielectric strength and endurance limit in either direction, but is recommended in high temperature applications because of its superior heat resistance. The six remaining laminates are suitable for high-voltage applications, Grade XXXP having the highest breakdown voltages perpendicular to laminations and Grade N-1 the highest parallel to laminations.

The author concludes that when selecting thermosetting plastics laminates as dielectric mediums, it would seem necessary to know the temperature at which the equipment will operate, the atmospheric conditions encountered, the mechanical strain, and the dielectric stress to be applied. If the material is used under dry conditions and the mechanical strength requirements are not severe, paper-base laminates are satisfactory. If humid conditions are present, the more water-resistant paper-base grades such as XXXP should be used. Under dry conditions requiring high mechanical strength Grade LE may be more effective, and under continuous humid conditions requiring high mechanical strength it may be necessary to use Grade N-1. If arc resistance is an important requirement Grade G-5 is indicated.

*(Contents Noted on page 174)*



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# Contents Noted

## New Method for Spotting Transformation Temperatures in Steels

A method for determining the temperature at which the transformation from austenite to martensite begins to take place in steels (Ms point) has been tested which seems to be as reliable as the metallographic method and, at the same time, to be much more rapid. The method employs the Curie point, at which temperature a cooling metal repossesses its magnetism. A cooling curve is plotted corresponding to the increasing magnetic permeability of the steel being quenched.

In a paper presented at the Thirty-sixth Annual Convention of the American Society for Metals, R. D. Chapman and W. E. Jominy of the Engineering Div., Chrysler Corp., described the equipment and results of tests conducted on 4 commercial steels: SAE 4340, 8642, 4140 and 52100. The equipment is simply an electrical transformer in which the specimen acts as a core. The specimen is heated to the critical point, then rapidly inserted in the apparatus, which consists of a glass oil-quench tank, a pick-up coil connected to a recording potentiometer, and an apparatus connecting a thermocouple from the specimen to a temperature recorder.

When transformation from austenite begins, the specimen begins to become magnetic. This magnetism induces an emf in the secondary coil, which is recorded on the potentiometer. Thus a curve can be plotted representing temperature vs magnetic permeability. The criterion of 1% transformation of austenite has been generally accepted for the beginning of transformation. Since the authors believed that in order to obtain 1% magnetic permeability, 1% transformation of austenite was necessary, the 1% permeability condition was selected as indicative of the Ms point. The results of tests showed quite good correlation

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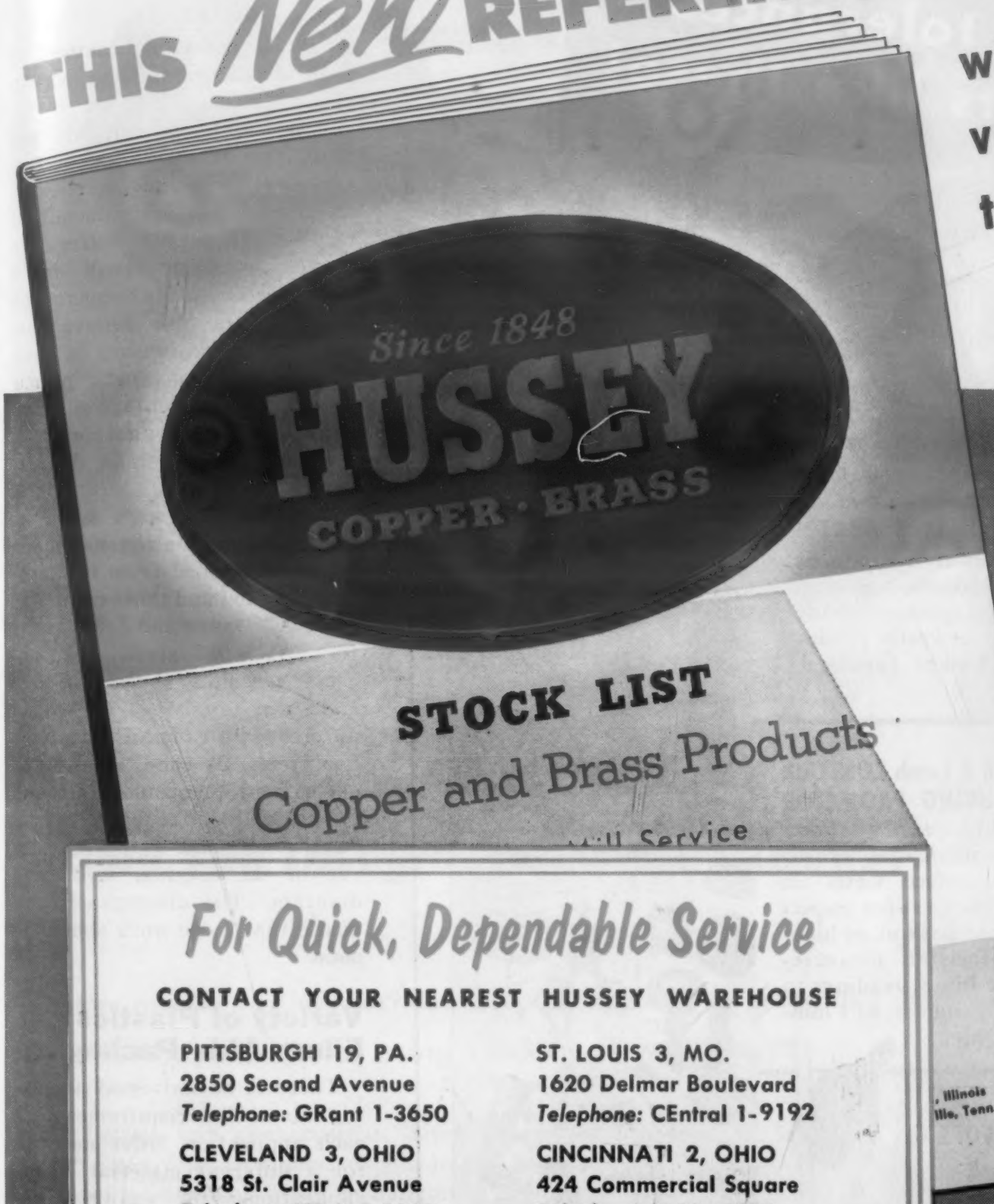


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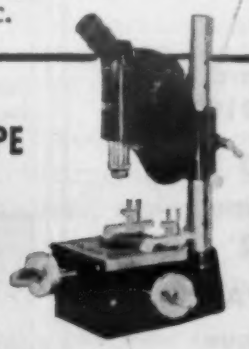

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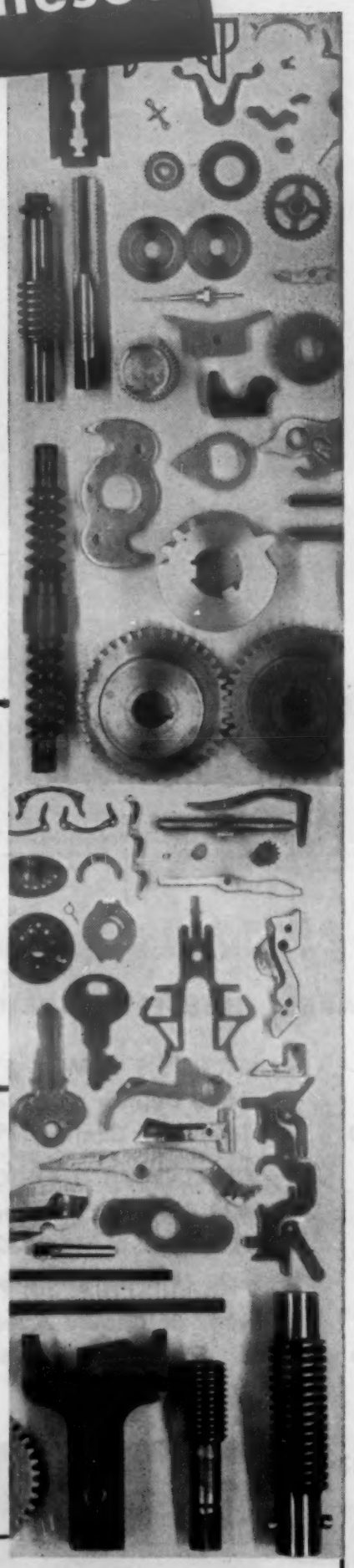

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## Contents Noted

with Ms points determined by both metallographic and calculation methods.

Like the metallographic method, the magnetic method is sensitive to inhomogenieties in the steel. A slight amount of banding or carbon segregation would definitely result in a higher recorded Ms temperature. The authors also believe that there is a relationship between percentage of magnetic permeability and percentage of martensitic transformation, but further work must be done to verify it.

Discrepancies were found to exist between continuous cooling curves developed from the magnetic method and those calculated by R. A. Grange and J. M. Kiefer for SAE 4063 steels. The authors speculate that these discrepancies might be due to 1) difference in composition of the two steels, 2) conditions of the experiment (continuously cooled vs calculated from isothermal conditions), and 3) possible error in the original isothermal diagram. The discrepancies indicate that more work should be done.

### Variety of Plastics Films Aids Packaging

There is no universal packaging film. The requirements of each application differ and call for a different material. Some applications, for example, demand of the film low water-vapor permeability combined with high oxygen permeability, while on the other hand, another application may demand of the film moderate water vapor permeability and very low oxygen permeability. This point was made by E. J. Koch of the Olin Film Div., Olin Mathieson Chemical Corp., in an address delivered before the Fifth Plastics Film, Sheeting and Coated Fabrics Div. Conference of the Society of The Plastics Industry, Inc. in December. Mr. Koch went on to discuss the various types of properties

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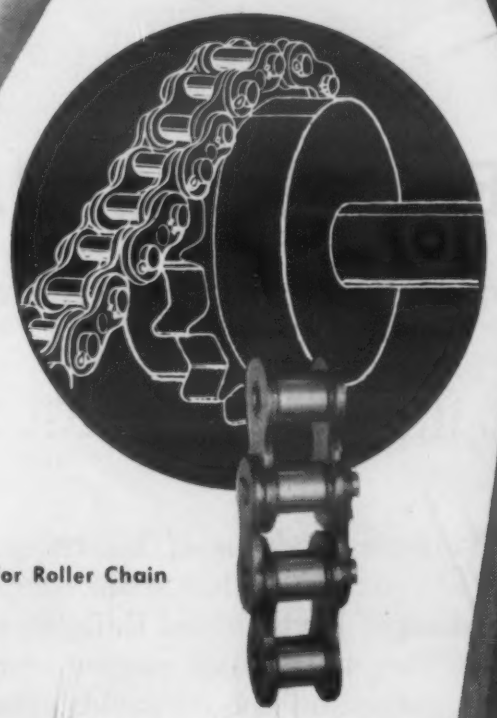

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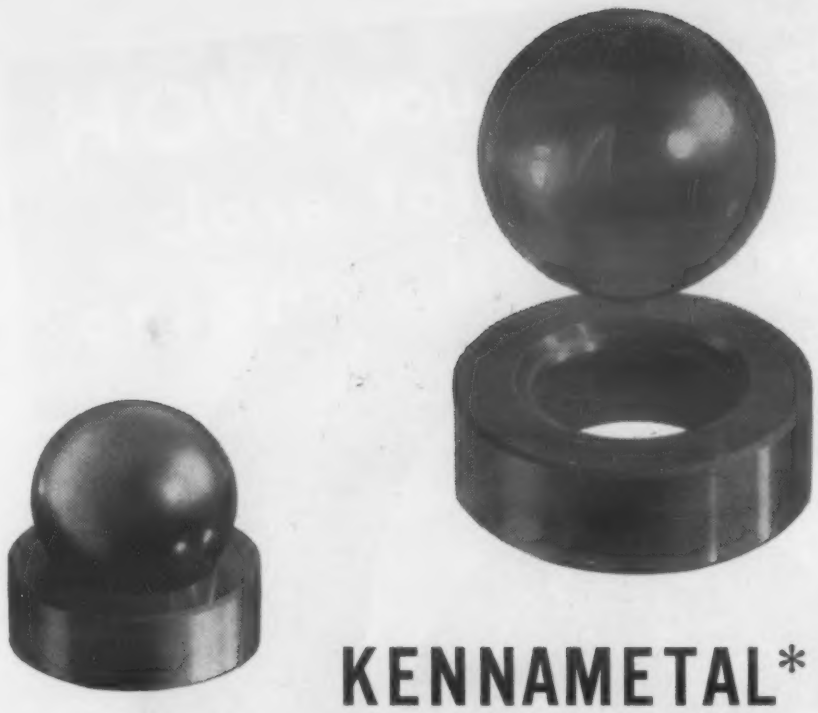

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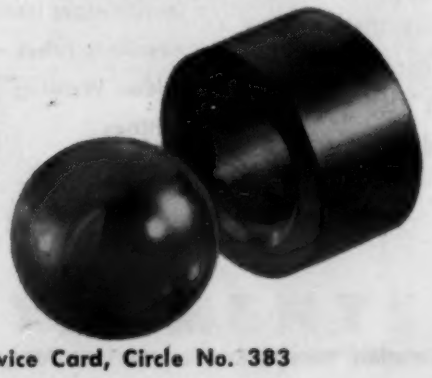


For more information, turn to Reader Service Card, Circle No. 383




# Contents Noted

required of such films, and the types of modified materials being developed.

### Materials available

Properties generally required in plastics packaging films include transparency, durability, purity (non-toxic for food wrapping), package-machine runnability (general properties allowing use of films in high production packaging machinery), specific functional properties dependent on the application, and low cost.

The various basic packaging films were discussed by Mr. Koch, summing up the characteristics and properties of each for packaging applications.

Plain cellophane is a transparent, printable, low cost film which cannot be heat-sealed while uncoated. The durability and gas-and water-vapor permeability vary with temperature and relative humidity.

Polyethylene is a translucent-to-transparent, flexible, heat-sealable film. It cannot be printed upon without suitable treatment. It is relatively poor at the present time in packaging machine runnability. Gas permeability is high, while water-vapor permeability is relatively low.

Cellulose acetate is transparent, dimensionally stable, and has high water-vapor permeability. It is printable but not easily heat sealed. Gas permeability is relatively high.

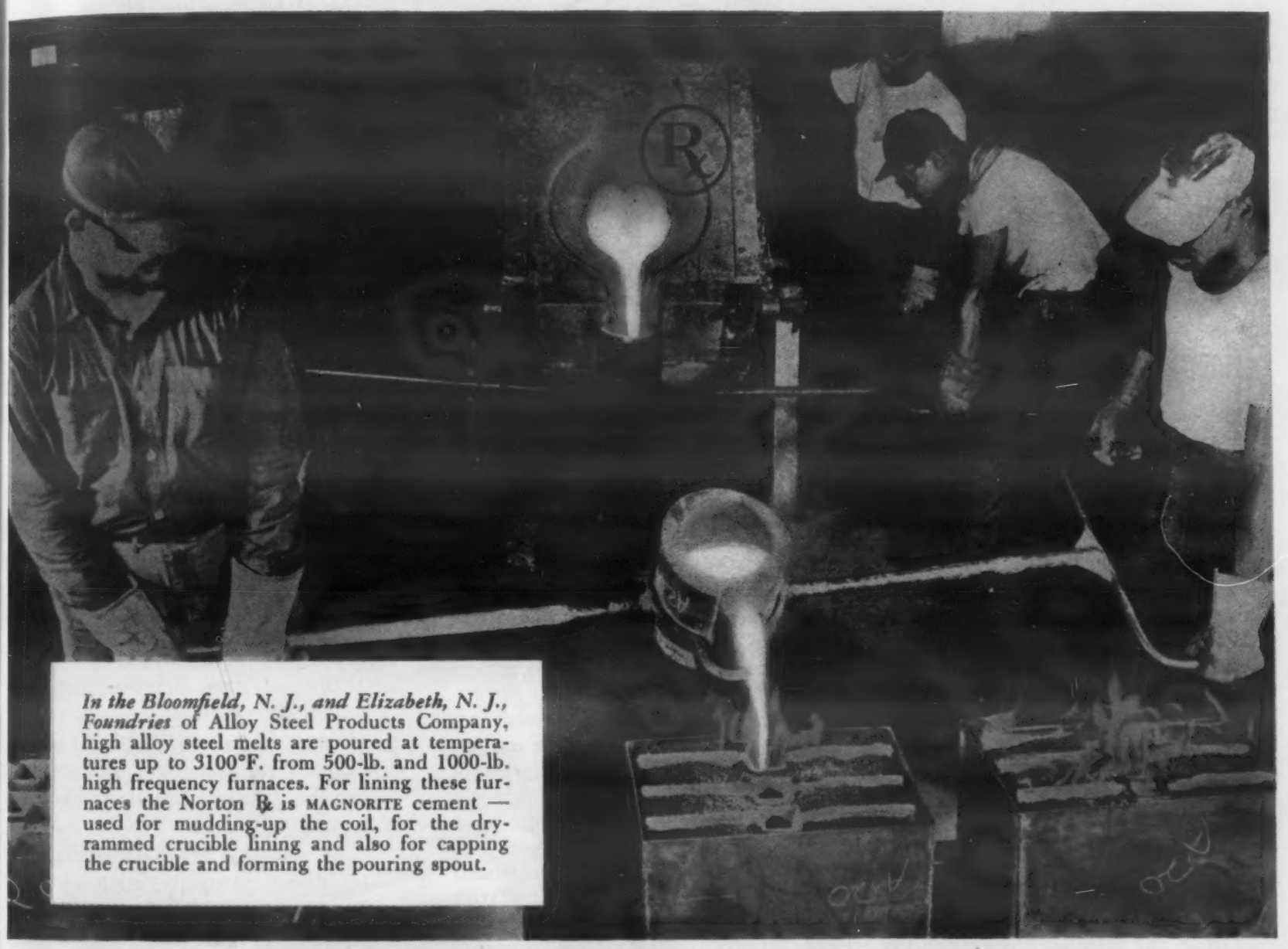
Rubber hydrochloride is a transparent, flexible, printable film. It is heat sealable and dimensionally stable. Its water-vapor permeability is low, gas permeability high. Because it is limp, packaging machine runnability is poor.

Polyvinylidene chloride is a transparent, greaseproof film with very low water-vapor and gas permeabilities. It is difficult to run on a packaging machine because of static and limpness. It must be electronically sealed.

Vinyl chloride is a transparent film with low water vapor permeability. In the past it also has

# *Another Norton Rx on the job!*

## *Makers of famous Aloyco Valves, after testing many cements, standardize on MAGNORITE**



*In the Bloomfield, N. J., and Elizabeth, N. J., Foundries* of Alloy Steel Products Company, high alloy steel melts are poured at temperatures up to 3100°F. from 500-lb. and 1000-lb. high frequency furnaces. For lining these furnaces the Norton Rx is MAGNORITE cement — used for mudding-up the coil, for the dry-rammed crucible lining and also for capping the crucible and forming the pouring spout.

Over the years the Alloy Steel Products Company, world's largest specialists in high alloy, corrosion resisting valves, have tested many refractory materials for the linings of their high frequency induction furnaces.

These tests proved that Norton MAGNORITE cement, engineered-to-the-job, lasted longer and performed better than any other material. As a result, Aloyco now uses MAGNORITE cement exclusively for lining these furnaces — still another example of how Norton refractories and refractory materials are *engineered and prescribed* to provide time-and-money-saving Rx's.

### *The Right Rx For YOU*

For your own induction furnace operations, Norton will be glad to engineer MAGNORITE cement to your exact requirements. It withstands temperatures up to 3250°F. Its high-rammed density offers great resistance to metal penetration, erosion and chemical attack. And it is designed to expand slightly when sintered so that the crucible lining is free from shrinkage cracks that often lead to furnace failures. Why not run a test on one of your furnaces soon?

This engineering service applies, of course, to any metal-melting problem you may have. Working with MAGNORITE*, ALUNDUM*, CRYSTOLON* and fused stabilized zirconia cements and special shapes, Norton engineers are sure to come up with the right answers. For details, see your Norton Refractories Engineer, or write to NORTON COMPANY, Refractories Division, 340 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

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**REFRACTORIES**

***Engineered... Rx... Prescribed***

*Making better products... to make other products better*

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

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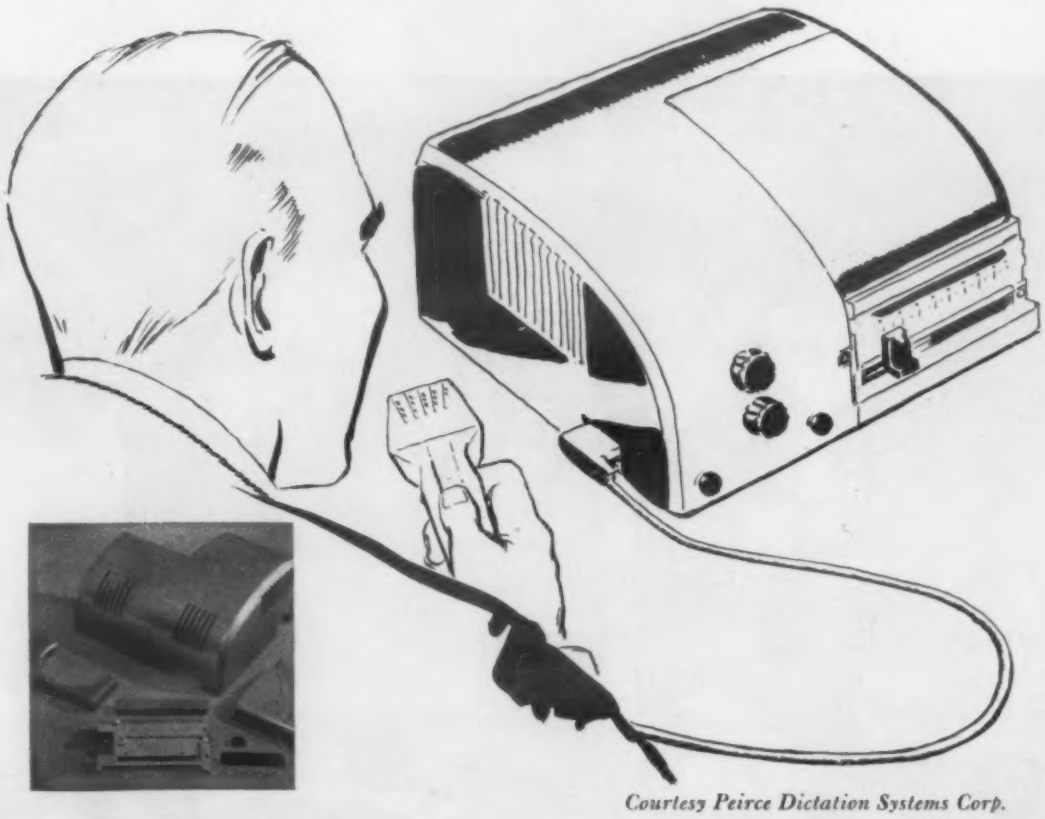
*Another up-to-date product gets...*

# TALKING POINTS
## *and* SAVINGS
## *with* DUREZ PHENOLICS



*Courtesy Peirce Dictation Systems Corp.*

These materials offer you a fruitful approach to savings on the production line as well as buyer benefits for your products. Either result is profitable... both are doubly so.

For example, a major part of finishing cost on this new Peirce Magnetic Belt Dictation unit was saved by using Durez for the five-piece molded case and dial panel. The desired color and quality of finish is applied by a low-cost process that would have been impossible on metal parts. Being self-insulating, the material prevents shorts in units. In two belt drum parts it also contributes to constant signal output needed for distortion-free recording.

Ease in maintaining rigid dimensional tolerances and ability to mold-in slots, holes, and threaded inserts also helped to hold cost down.

Whether or not you are already using plastics, it will pay you to inquire into the phenolics today. Interesting new developments by Durez are extending the industrial importance of these highly versatile materials.

Call on our 34 years of specialized experience for help in solving your materials problems. You'll find interesting reports in our illustrated monthly "Plastics News." Write Durez Plastics & Chemicals, Inc., 1401 Walck Road, North Tonawanda, New York.

**MOLDING COMPOUNDS.** Structural, electrical, and chemical properties in many combinations.

**RESINS FOR INDUSTRY.** Bonding, casting, coating, laminating, impregnating, and shell molding.

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# Contents Noted

been difficult to run on packaging machines. Its properties are greatly dependent on the type and quantity of plasticizer used.

Mylar polyester film is transparent, has high strength with low gas permeability and moderate water-vapor permeability. It must be impulse sealed and at present has poor packaging machine runnability.

Aluminum foil is a reflective, stiff film with low water-vapor and gas permeabilities. It is printable but difficut to use in packaging machines. It cannot be heat sealed and is particularly poor in abrasion resistance.

### Modification methods

Four basic methods are used to modify the films for specific uses:

1) *Modification of the base film*—Additives to the base film may be used to impart flexibility, strength, slip, an anchorage base for coatings, to aid in control of permeability and to help obtain optical characteristics.

2) *Physical modification*—Many of the plastics can be physically treated to increase strength or modify optical properties. In some cases the film can be treated to alter the molecular structure of the surface making it more receptive to other materials, such as ink. Perforation of the film can allow passage of gas in or out of the package, and reduce water condensation on the interior surfaces.

3) *Coatings*—Coatings are used to provide varied gas and water vapor permeabilities, optical properties, slip, heat sealability, printability, resistance to grease, or as a base for laminations. Nitrocellulose and polymeric coatings, wax or a combination of these may be used. Such materials as cellulose nitrate, synthetic rubbers, vinyl acetate, vinyl chloride and vinylidene chloride polymers are also used. In general, coatings allow the use of a low cost, high strength base film which may be

For more information, Circle No. 382 ▶

# How the use of NATIONAL Seamless EXTRUDED Stainless Tubing *cuts nut manufacturing costs*

USING NATIONAL Seamless EXTRUDED USS Stainless (type 303) Tubing, the Tri-Clover Division of Ladish Corporation is now turning out hexagonal nuts in less time and at lower cost than they could using solid bar stock. The savings in material cost alone amounts to 11.77 cents per piece.

All machining on the nuts, except threading and O.D. finishing, is done in one operation on a 6-spindle, 3½ inch Conomatic automatic machine. A saving of five seconds in the time cycle was made by using the extruded hexagonal stock versus bar stock. The use of hex tubing has eliminated the cost and upkeep of boring tools —and, because tubing is considerably lighter than bar stock, it can be handled faster and with less difficulty.

NATIONAL EXTRUDED Tubing offers you high strength, uniformity, and dependability that only *seamless* tubing can give. For a better precision part, involving fewer operations and fewer machine hours, investigate NATIONAL Seamless EXTRUDED Tubing—made by the world's largest manufacturer of tubular steel products. Feel free to call our engineers if you'd like help in applying NATIONAL Seamless to your product.

* * *

***National Tube employs a hot-extrusion process known as "Sejournet" in which white-hot billets of steel are squeezed into tubing of various shapes by a 2,500-ton hydraulic press and ram—a manufacturing method that insures absolute uniformity of wall strength.***

**NATIONAL TUBE DIVISION**
**UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.**
***(Tubing Specialties)***

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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USS TRADE MARK

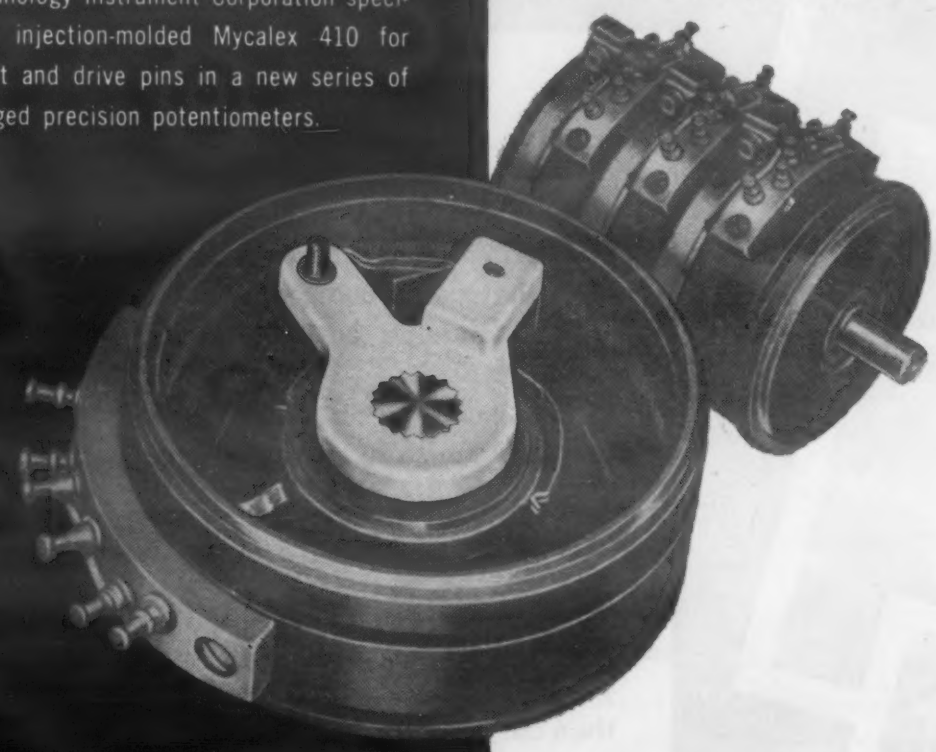
## NATIONAL Seamless EXTRUDED TUBING

WALLS WITHOUT WELDS

UNITED STATES STEEL

For Absolute dimensional stability...specify MYCALEX
GLASS-BONDED MICA

After testing numerous design materials, Technology Instrument Corporation specified injection-molded Mycalex 410 for shaft and drive pins in a new series of ganged precision potentiometers.



By permitting closer dimensional tolerances, Mycalex glass-bonded mica allows TIC to reduce the size and hold these dimensions constant under toughest environmental conditions. And dimensional stability of the Mycalex coupling arm provides precision transference of rotary shaft motion between adjacent potentiometers without backlash.

For more details on this exciting material and its application to your design problem, write to General Offices and Plant: Department 124 Clifton Boulevard Clifton, N. J.

TIC designers are typical of the hundreds of electrical and electronic engineers who have discovered the outstanding qualities of Mycalex. Important Mycalex properties include:

* low electrical loss factors
* high dielectric strength
* permanent and absolute dimensional stability
* impervious to water, oil and organic solvents
* very high arc resistance with complete freedom from carbonization

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MYCALEX CORPORATION OF AMERICA

World's largest manufacturer of glass-bonded mica products

Executive offices: 30 Rockefeller Plaza New York 20, N. Y.

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# Contents Noted

inadequate in many properties when uncoated.

4) *Lamination*—Laminating two or more films to form one packaging sheet combines the advantages of each of the materials used.

## High Temperature Strength of Zirconium Alloys

Zirconium is a potentially attractive metal for high temperature service due to its high melting point (3325 F). However, its mechanical properties are relatively poor at elevated temperatures. Experimental work has been carried out on the effects of binary additions of chromium, columbium, molybdenum, tantalum, tungsten and vanadium on workability, hardness and strength of wrought zirconium at temperatures of 1800 to 2200 F.

In a paper presented at the Thirty-sixth Annual Convention of the American Society for Metals, H. A. Saller, J. T. Stacy and S. W. Porembka of Battelle Memorial Institute describe the procedure employed and the results of their work.

### Results summarized

Alloys of tantalum or tungsten were found to be the most easily worked, while vanadium or chromium alloys were the least workable. Tungsten was found to be very effective in strengthening zirconium at temperatures of 1800-2200 F, but care is required to produce homogeneous alloys by arc melting. Comparison with commercial alloys in this temperature range shows that zirconium-tungsten alloys approach the strength of Inconel or Type 310 stainless steel at 2200 F.

The authors conclude that the metals of Group 6 of the Periodic System are more effective in strengthening zirconium at 1800-2200 F than those of Group 5. For a given group, the heavier the metal, the more effective it is as a strengthener, and the less it reduces hot workability

# holes in GRAMIX® parts *are practically FREE!*

**Oil holes, vent holes and similar small holes can usually be made in GRAMIX sintered metal parts at no cost to you. That's because holes are die-pressed into GRAMIX parts, not drilled. And in production quantities the metal saved often offsets the slight additional cost of the dies. GRAMIX parts can be produced in relatively complicated shapes to tolerances as close as .0005". They cost less than similar machined parts, and they can be oil-impregnated for self lubrication. Write today for full details.**

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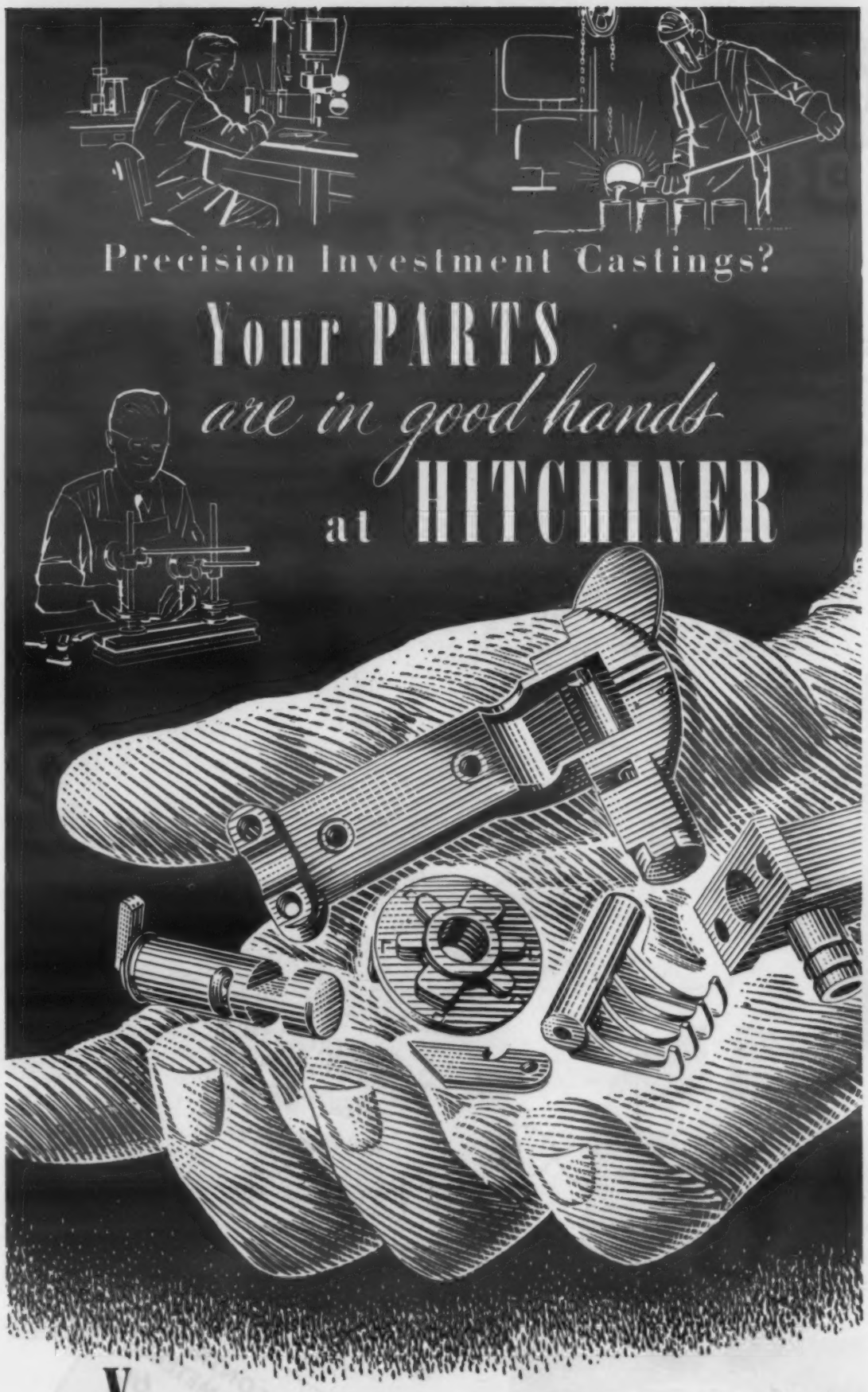


YES, Hitchiner's broad experience and complete facilities — exclusively devoted to producing precision investment castings — can be a profitable factor in the success of your product. The reason? From die shop to research and testing laboratories to heat treating department . . . every step in the fabricating of your component parts is under the direct supervision of top management and in the competent hands of Hitchiner craftsmen.
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## news of ENGINEERS COMPANIES SOCIETIES

### NEWS OF ENGINEERS

**Harrison O. Ash** has been elected president and general manager of Aluminum Industries, Inc. to succeed **John W. Craig** who recently resigned to become vice president and general manager of the RCA-Victor Home Appliance Div., Radio Corp. of America.

**Harry Engvall,** formerly chief engineer of the Turbine and Gear Depts., De Laval Steam Turbine Co., has been promoted to executive engineer. **John S. Haverstick** will assume Mr. Engvall's former post.

**Ralph A. Rockwell** has been appointed chief engineer for the Valve Div., Minneapolis-Honeywell Regulator Co.

**Edward H. Freiburghouse, Jr.** has been named manager of the new mechanical engineering sub-section in General Electric Co.'s Materials and Processes Laboratory.

**Frank Klima** has been named manager of Kaiser Aluminum & Chemical Corp.'s newly acquired aluminum forging plant at Erie, Pa.

**William A. Martin** has been appointed works manager of the Marine & Industrial Div., Chrysler Corp.

**William F. Zarbaugh** who has been serving as assistant general manager, Cold Metal Products Co., has been appointed a vice president of the company.

**Lawrence C. Houdek** has been appointed division engineer of the Adhesives and Coatings Div., Minnesota Mining & Manufacturing Co.

**Eugene M. Smith** has been appointed to the position of assistant director of research, Lukens Steel Co.

**Ronald D. Gumbert** has been elected president and member of the board, Alloy Precision Cast-

# ARE WE IN YOUR FILES?

As a dependable source for
**MAGNESIUM FABRICATION**
and
**MAGNESIUM SAND CASTINGS**

Whether you plan the development of a new product, or are seeking ways to further improve existing ones, you may want to look into the many new avenues which are open to the design engineer who includes magnesium in his basic planning.

Magline Inc.—one of America's leaders in magnesium—has prepared a descriptive new bulletin, expressly outlining for designers and engineers, the company's services as a reliable, experienced source for magnesium sand castings and magnesium fabrication. Specialists in magnesium exclusively, we believe that our background and experience qualifies us well to serve you in: (1) objectively searching out applications for product improvement through magnesium, (2) assisting in the design and development phases, (3) producing the required parts and components in any quantity, to your exact specifications. May we send you a copy of Bulletin No. 50?

**COMPLETE FACILITIES FOR:**

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MagLine

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# . . . Tyer Research Helps Remington Solve a Sticky Problem!

"Here's the finished gasket,"
A. H. Thomas, Tyer Sales Engineer,
tells Mr. Andrew E. Reiss, Project Engineer,
Remington Corporation, Air Conditioning Division.

Remington room air conditioners are used in 68 countries – many of them in hot, humid tropic regions. To assure dependable performance of these units in *any* climate, a special molded rubber gasket was required. The Remington Corporation asked Tyer engineers for assistance in solving the problem.

The answer proved to be a gasket which (1) forms a complete seal around the cabinet without pressure or cement, (2) permits side wing seals to interlock, (3) ensures leakproof performance and age-resistance even in extreme temperatures.

Tyer is proud of its contribution to the success of the Remington air conditioner, a product that is internationally acclaimed for its excellence.

If *you* have a problem involving rubber, call in a Tyer Sales Engineer. Write Dept. 93, for our "Molded and Extruded" catalog.

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**RUBBER COMPANY**
*The Unusual in Rubber Since 1856*
**ANDOVER, MASSACHUSETTS**

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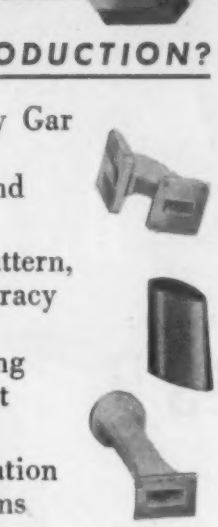
**for ABSOLUTE ACCURACY in QUANTITY PRODUCTION?**

This unique electroforming process was developed by Gar to give you quantity production of full-formed, or sheet parts — to reproduce dimensional accuracy and surface finish to the thickness of a single atom.

Using electrolytic build-up of the part on a master pattern, this process is uniquely suitable where internal accuracy and surface finish are critical. Gar-forming also permits "growing" of other components in place during part formation, to produce integral assemblies without fabrication distortion.

For production or prototype runs, the wide application possibilities of Gar-forming offer new, practical solutions to design and production problems. Send us your specifications . . . let us show you the specific advantages this unique process can offer you.



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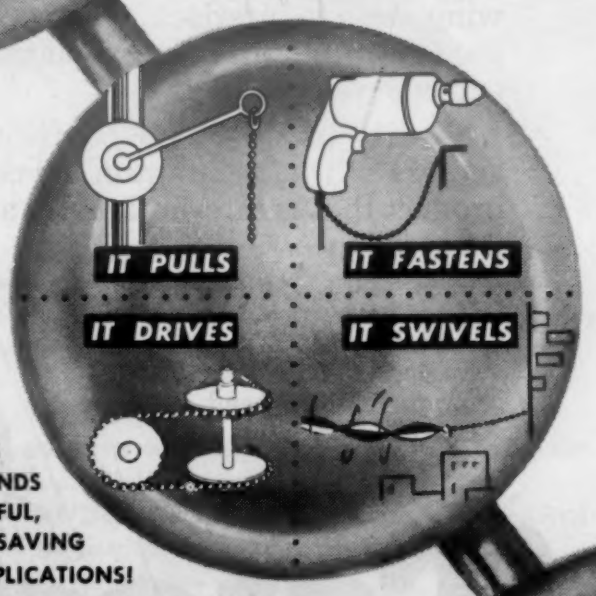
take advantage of *Versatile* **BEAD CHAIN**




IT HAS THOUSANDS OF USEFUL, COST-SAVING APPLICATIONS!

Bead Chain is available in 5 diameters from 3/32" to 3/8" with tensile strengths ranging from 18 to 200 lbs., in a variety of metals and finishes. No matter what the requirement, our engineers will be glad to assist you in solving your chain applications.

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**THE BEAD CHAIN** MANUFACTURING CO.
15 Mountain Grove St., Bridgeport, Conn.

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## news of ENGINEERS

ings Co. Mr. Gumbert served as executive vice president for the past two years.

**G. Allen Lovell** has been named assistant general manager of the Mechanical Goods Div., United States Rubber Co. Mr. Lovell replaces **Herbert G. Kieswetter** who has been named executive assistant to the general manager of the company's International Div.

**Walter F. Hinkle** has been elected vice president of engineering, Acme Steel Co.

**A. W. Morgan** has been appointed assistant manager-operations, Convair, a Division of General Dynamics Corp. Other new appointments include **George A. Covington** as assistant to the manager, and **Roy H. Gilliland** as manager of quality control.

**John E. Haig,** vice president and secretary of Ajax Electric Co. has been elected president of that company to succeed **William Adam, Jr.,** who died November 1.

**Dr. Wesley S. Coe** has been appointed assistant to the vice president and general manager of the Naugatuck Chemical Div., United States Rubber Co.

**Raymond E. Hewlett** has been appointed staff project engineer and **Brent C. Jacob, Jr.,** chief industrial engineer of the Chrysler Div., Chrysler Corp.

**Dr. A. R. Powell** who has been associate manager of the Central Research Dept., Koppers Co., Inc., since 1949, has been named acting manager of that department following the resignation of **Dr. G. F. D'Alelio.** Dr. D'Alelio will remain with the company for the time being to carry out a special project on high-impact plastics.

**J. Robert Ferguson, Jr.,** has been appointed chief engineer-project development, United States Steel Corp. Mr. Ferguson succeeds **Norman C. Michels** who was recently appointed assistant vice president in charge of engineering, for the company's Tennessee Coal & Iron Div.

*(News of Companies on page 187)*

## news of | COMPANIES

**Pressed Steel Car Co., Inc.** has formally adopted a new name, U.S. Industries, Inc.

**Acheson Industries, Inc.** recently announced plans for the immediate construction of a new plant to supply polyethylene producers with dispersed pigments and carbon black at Orange, Texas. The new plant will be known as Acheson Dispersed Pigments (Texas) Inc.

**Nytef Plastics, Inc.,** Kenilworth, N.J. with sales offices and warehouse located at 630 Broadway, New York City, has been formed to specialize in the extrusion of rigid nylon (Zytel 101) rods, tubes and shapes.

The **James F. Lincoln Arc Welding Foundation** has announced the eighth annual competition of its engineering undergraduate design program for the 1954-55 school year. The program offers 46 awards for papers of no more than 20 pages presenting the welded design of a machine, machine part, structure or structural part. The top award is $1250.

**Inland Steel Co.** has announced plans for an expansion of more than 60 per cent in its capacity to produce galvanized steel sheets. A third continuous line for their production by a process for coating sheets with zinc will be installed at its Indiana Harbor, Ind., works.

**Babcock & Wilcox Co.** has purchased the assets and business of **Globe Steel Tubes Co.** of Milwaukee. The Milwaukee plant will be operated as a part of Babcock & Wilcox Co.'s Tubular Products Div.

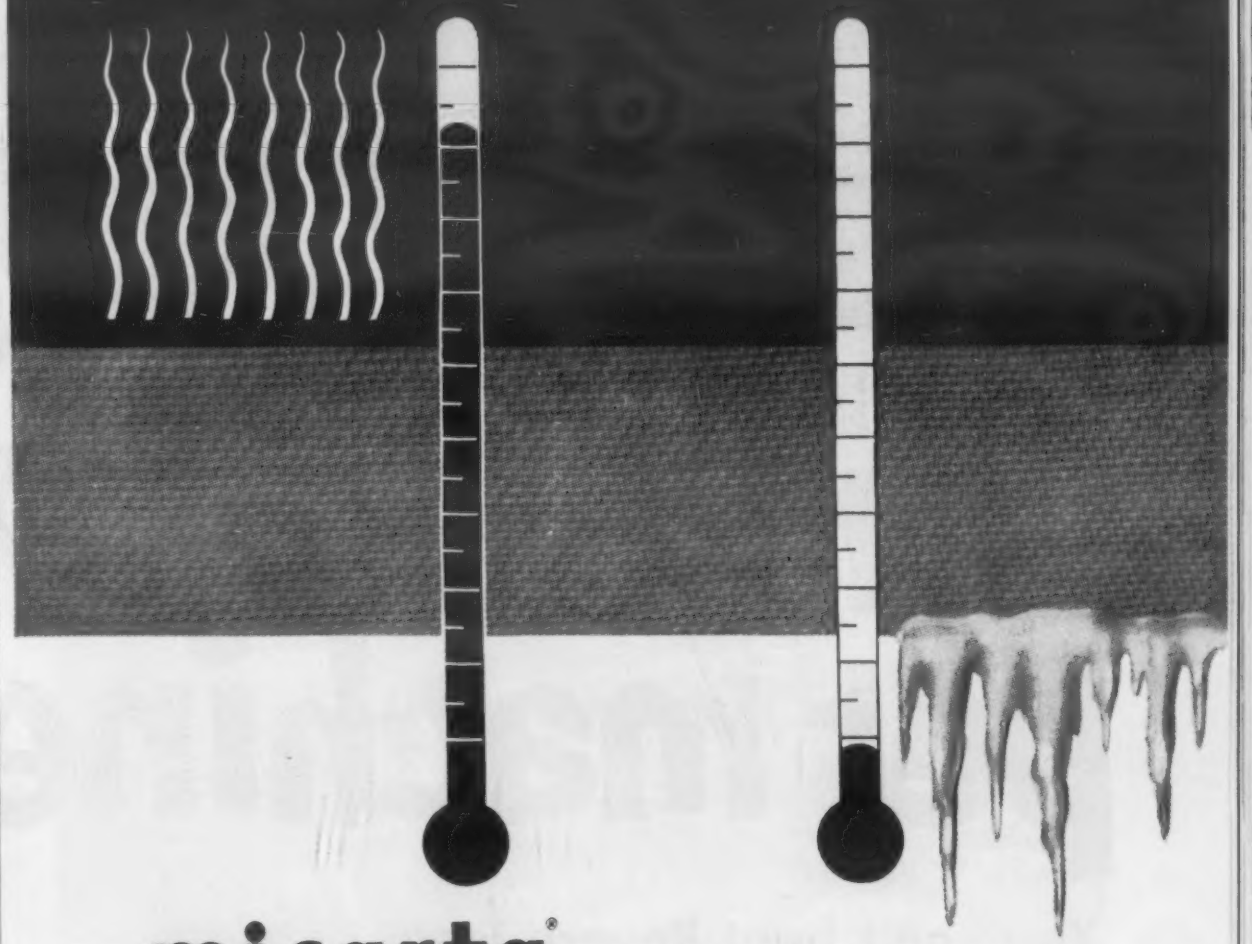
**H. K. Porter Co.** has purchased the **Riverside Metal Co.,** Riverside, N.J.

**Carpenter Steel Co.** has put into operation a new hot rolling mill which makes possible the production of strip, rods and bars on one combined layout.

**ACF Industries, Inc.** has acquired **Engineering and Research Corp.** of Riverdale, Md.

*(News of Socities on page 189)*

When you're looking for a material that resists TEMPERATURE EXTREMES...



micarta® is basic!

At below zero, or extremely high temperatures, MICARTA retains the properties that make it one of industry's most versatile materials. It resists compression and impact. It withstands vibration and muffles noise. It repels moisture ... fights corrosion. It is an excellent insulator. How can this lightweight, easily fabricated material help you? Use the coupon for the complete story.

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YOU CAN BE SURE...IF IT'S Westinghouse

MICARTA's Unique Properties are serving every industry in applications ranging from tiny punched parts to massive steel mill bearings.

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☐ Please have your representative call

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MM-1-55

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# 4500 per hour per machine!

## You can't beat Revere Free-Cutting Brass for speed

The mounting nuts shown here are made by the Fischer Special Mfg. Co., Cincinnati 6, Ohio, out of Revere 9/16" hexagon Free-Cutting Brass Rod. Output is 4500 per hour per machine. This phenomenal rate of production is due to special adaptations of standard machines according to Fischer designs and the high quality of Revere Rod. These two important factors enable Fischer to compete price-wise with nuts produced by other methods.

Fischer nuts are chamfered and countersunk on both sides, have no burrs, and are made in sizes from 1/8" to 1-1/16", in various designs, such as hexagon, cap, thumb, spark plug terminal, lighting fixture. As a further indication of the efficiency of the Fischer operation it can be reported that during 1953 the company averaged 244,897 pieces per running hour.

If you machine brass, look into the virtues of Revere Free-Cutting Brass. See the nearest Revere Sales Office.

**REVERE**

**COPPER AND BRASS INCORPORATED**

*Founded by Paul Revere in 1801*

230 Park Avenue, New York 17, New York

*Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere*

**FISCHER WAFER** or mounting nuts, made from Revere 9/16" Free-Cutting Brass Rod at a rate of 4500 per hour.

Revere Free-Cutting Brass Rod has speeded production for many firms, and saved them money.

For more information, turn to Reader Service Card, Circle No. 360

## news of | SOCIETIES

The **American Welding Society** elected the following officers at its recent national fall meeting; Joseph H. Humberstone, president, Air Reduction Sales Co., Inc., president; J. J. Chyle, director of welding research, A. O. Smith Corp., 1st vice president; C. P. Sander, general superintendent, Vernon Calif. Plant, Consolidated Western Steel Div., United States Steel Co., 2nd vice president.

The **Gray Iron Founders' Society** at its recent annual meeting, elected the following new officers: C. H. Ker, president, the Dalton Foundries, Inc., president; J. W. Simmons, Jr., secretary-treasurer, Cox Foundry & Machine Co., vice president.

The **American Society for Testing Materials** has named Frank Y. Speight as assistant technical secretary.

The **Magnesium Association** has elected D. T. Wellman, president, Wellman Bronze & Aluminum Co., as president and James E. Pepall, president, Magnesium Co. of Canada, Ltd., as vice president.

The **National Association of Corrosion Engineers** has selected Gordon N. Scott, consulting engineer in Los Angeles, and W. H. Vernon of England to receive its 1955 awards. These awards will be made during the Society's annual conference and exposition in Chicago on March 7-11. Dr. Scott will receive the *Frank Newman Speller Award* for achievements in corrosion engineering and Mr. Vernon will receive the *Willis Rodney Whitney Award* for achievements in the field of corrosion science.

Latest developments in welding and unique applications of welding processes will be discussed February 8 and 9 at the first annual Midwest Welding Conference at **Armour Research Foundation of Illinois Institute of Technology**, Chicago.

*(Meetings & Expositions on p. 190)*


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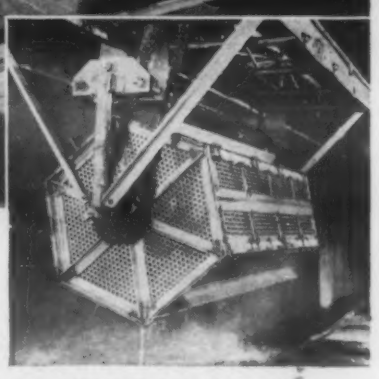

*Man kneeling at left is adjusting faucet of "Alodine" tank. All tanks hold 5,500 gallons. Note simplicity of operation.*

*Small aluminum parts are Alodized in this power-driven squirrel cage tumbler.*

Practically all painted aluminum aircraft parts at Temco are pre-treated with "Alodine."

*If it's aluminum, be sure it's Alodized.*

Alodizing improves paint-bonding and enhances aluminum's natural corrosion-resistance.

Alodized aluminum effectively meets the requirements of Military Specification MIL-C-5541.

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INDUSTRIAL HEATING EQUIPMENT ASSN., INC., annual meeting. Detroit. Jan. 24-25, 1955.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, Annual meeting. Philadelphia. Jan. 24-27, 1955.

INSTITUTE OF THE AERONAUTICAL SCIENCES, annual meeting. New York. Jan. 24-28, 1955.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter meeting. New York. Jan. 31-Feb. 4, 1955.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Cincinnati. Jan. 31-Feb. 4, 1955.

SOCIETY OF THE PLASTICS INDUSTRY, INC., annual Reinforced Plastics Div. conference. Los Angeles. Feb. 8-10, 1955.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, annual meeting. Chicago. Feb. 14-17, 1955.

SOCIETY OF THE PLASTICS INDUSTRY CANADA, INC., annual SPI Canadian conference. London, Ontario, Canada. Feb. 22-23, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. March 1-3, 1955.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, annual conference and exposition. Chicago. March 7-11, 1955.

NATIONAL ELECTRICAL MANUFACTURERS ASSN., winter meeting. Chicago. March 13-18, 1955.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. March 14-15, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting and forum. Cincinnati. March 14-16, 1955.

AMERICAN SOCIETY OF TOOL ENGINEERS, annual meeting. Los Angeles. March 14-18, 1955.

AMERICAN SOCIETY FOR METALS, Western Metal Congress and Exposition. Los Angeles. March 28-April 1, 1935.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Pacific Coast section conference. Palm Springs, Calif. April 13-15, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aeronautic production forum and aircraft engineering display. New York. April 18-21, 1955.

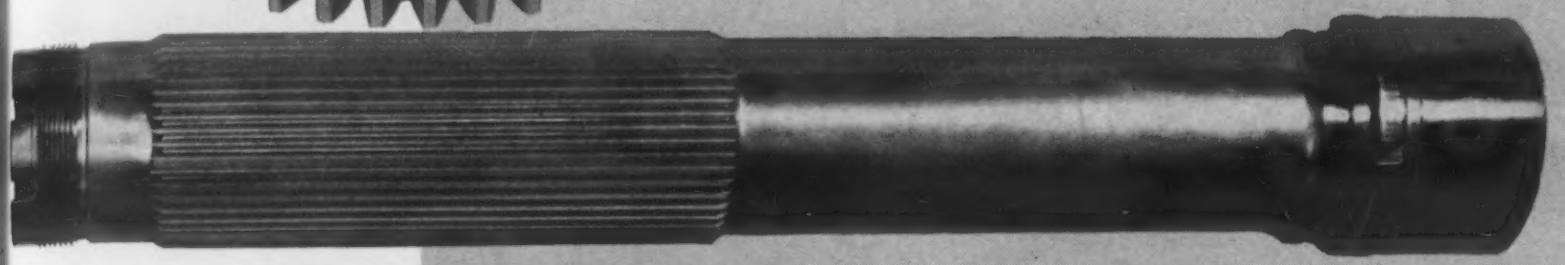
ELECTROCHEMICAL SOCIETY, INC., spring meeting. Cincinnati. May 2-5, 1955.

SOCIETY OF THE PLASTICS INDUSTRY, INC., annual meeting. Queen of Bermuda. May 7-15, 1955.

METAL POWDER ASSOCIATION, annual meeting. Philadelphia. May 10-12, 1955.

**Basic Materials Conference and Exposition. Philadelphia. May 31-June 3, 1955.**

Typical gear and spline processed by Wright Aeronautical Corp.



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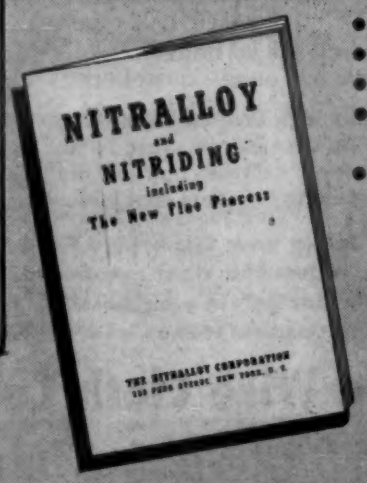


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# News Digest

continued from page 11

In the hot chamber process, as perfected for zinc alloys, the lower melting temperature of the alloy permits the charging cylinder and piston to operate while submerged in molten metal, and no individual shot ladling is necessary. Aluminum is not suitable for the hot chamber process, as it alloys with and dissolves the steel cylinder and piston materials.

### Dow's hot chamber

The hot chamber machine which yielded the cost data above is a modified 70-ton zinc hot chamber casting machine. The metal feed mechanism has been rebuilt with high temperature resistant steel and the flow system modified to prevent air contact with the molten metal. The surface area and volume of the molten magnesium are held to an absolute minimum by means of a "continuously supplied gooseneck". Rather than submerging the gooseneck in molten casting metal, the gooseneck is heated by a small furnace and is fed through a closed pipe from the supply pot. An automatic, electrically controlled valve, operating from a sensing electrode in the gooseneck, keeps the metal at the proper level.

Molten metal in the supply pot is shielded by flux and protective atmosphere. The gravity feed tube from the supply pot to the gooseneck is electrically heated. A hydraulically operated piston forces the metal through the gooseneck to the vertical parting-plane die.

The machine can be set to run automatically, but complex parts usually require close attention at the die.

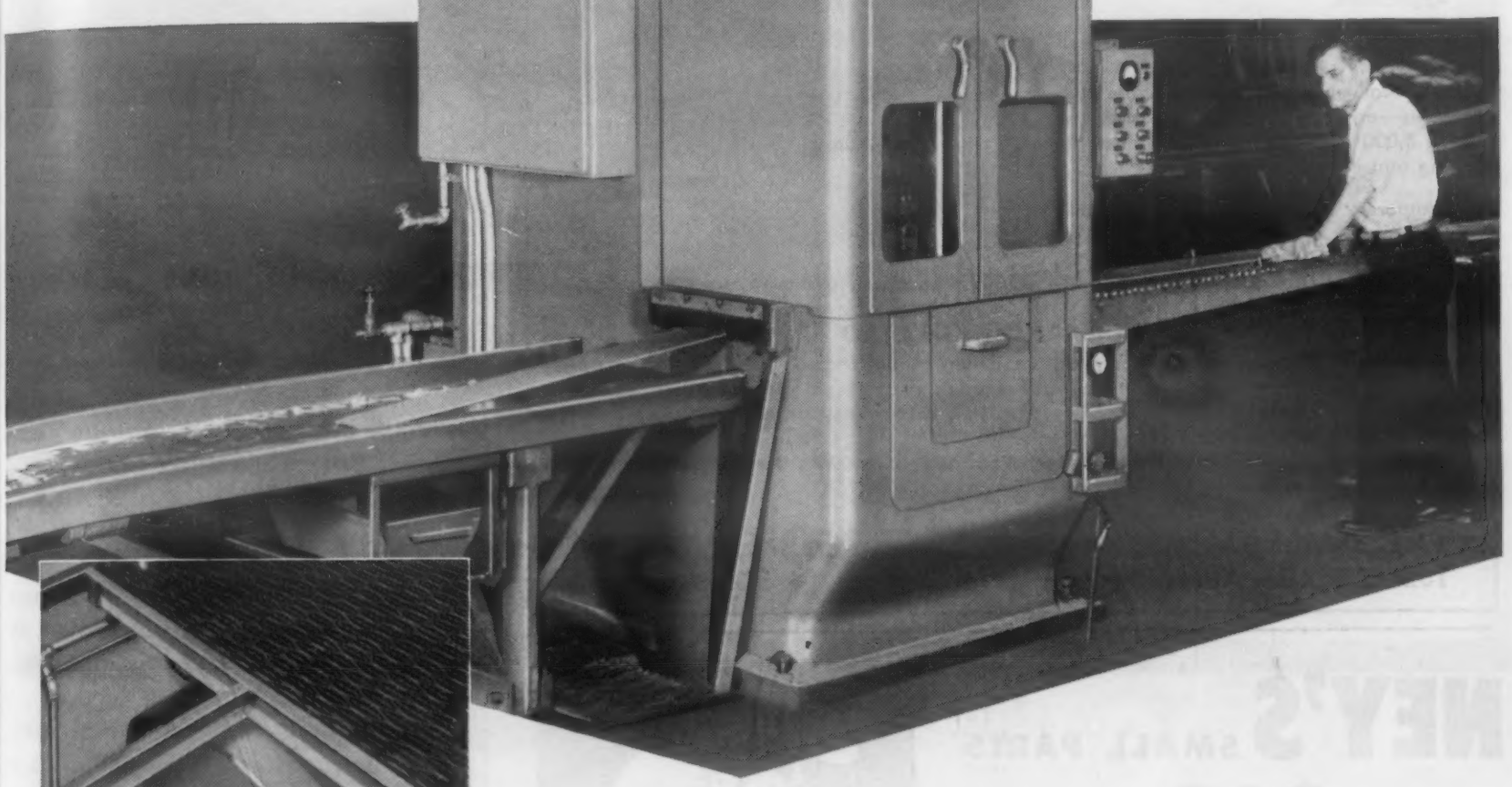
### Work continues

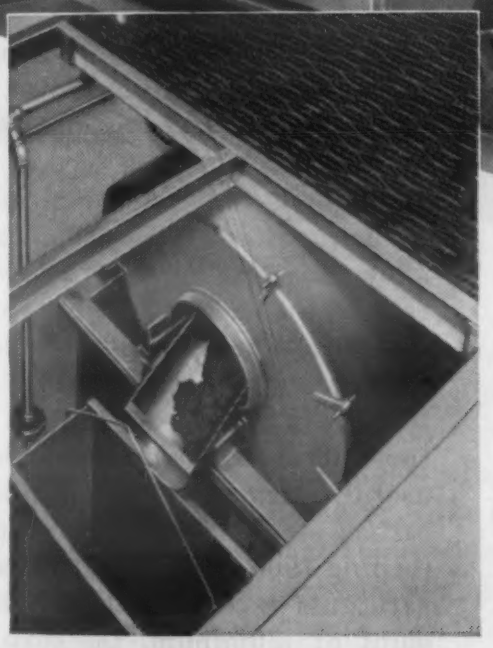
Dow engineers have been working on an automatic cold chamber shot charging and metering device for several years, and report that the work on this alternative device will go on despite development of the hot chamber machine.

*(More News Digest on page 194)*

MURRAY WAY

# MICRO-POLISH strip grinding boosts output over 600 percent for Michigan manufacturer





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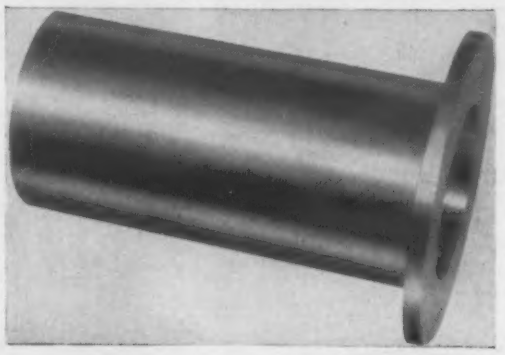

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# News Digest

**A steel part** is dipped into molten aluminum alloy in the Alumicoat process.

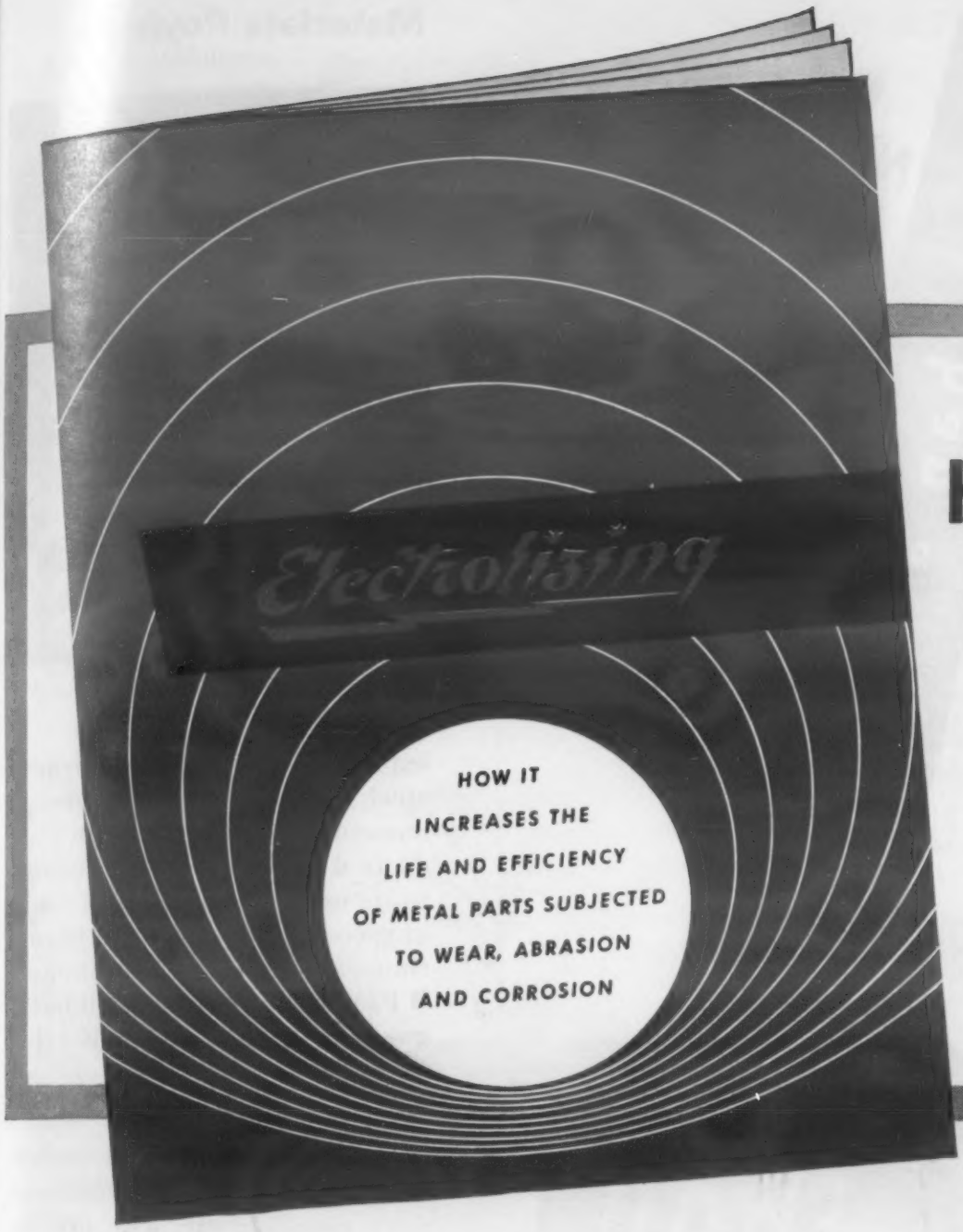
## G. M. Licenses Aldip to N. Y. Concern

Commercial facilities for coating ferrous alloys with aluminum have been set up by Arthur Tickle Engineering Works, Inc., Brooklyn, N. Y. Under license from General Motors Corp. General Motors has used the process successfully for coating exhaust valves and other parts subject to corrosive conditions at high temperature.

The aluminum coating process, which provides an iron-aluminum alloy molecular bond at the interface of the coating and base material, will protect mild and low alloy steels from oxidation at temperatures at least as high as those at which the base metal has useful strength. Tests on low carbon steel at temperatures exceeding 1900 F show that at temperatures exceeding the melting point of aluminum, the coating metal diffuses into the steel and still provides protection due to the aluminum oxide intermetallic material that forms on the surface.

Pure aluminum or a variety of alloys make suitable coating materials. Pure aluminum has been found to offer the best resistance to attack of industrial gases and corrosive media containing sulfur compounds.

The new Arthur Tickle plant has facilities for handling large parts such as furnace stacks and boiler components. The process will be marketed under the trade name "Alumicoat".

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## Materials Review

*continued from page 14*

**Research dug deeper** into the nature of metals and alloys.

experience with hot extruded steel shapes. ■ Dow Magnesium announces that sheet and plate up to 6 ft wide will be produced in its new rolling mill as a result of successful development of continuous ingot casting techniques. ■ Precoated sand for shell molds goes on the market. (Bakelite Co.)

**July**

■ Work on upgrading chromium nickel stainless shows promise of final results that will provide substitutes for some superalloys in the 1500 F temperature range. ■ Vacuum forming of plastics sheet has grown so fast many think it is oversold. ■ The Government decides to start stockpiling lead and zinc rather than raise tariff. ■ Industry reports on titanium show conflicting opinions—some say they can't get uniformity, others say that the metal is fine. ■ A new high tear-strength elastomer is made from silicone and Teflon. ■ Goodrich shows how to form rigid vinyl sheet on conventional metal stamping equipment. ■ An aluminum pigmented neoprene coating is put on the market. ■ Alcoa squeezes out the first production extrusions from the heavy press program 14,000-ton extrusion press. ■ A low erosion phenolic molding compound is developed by General Electric as a result of research on die wear using radioactive isotopes. ■ A new method for drawing shapes from metal

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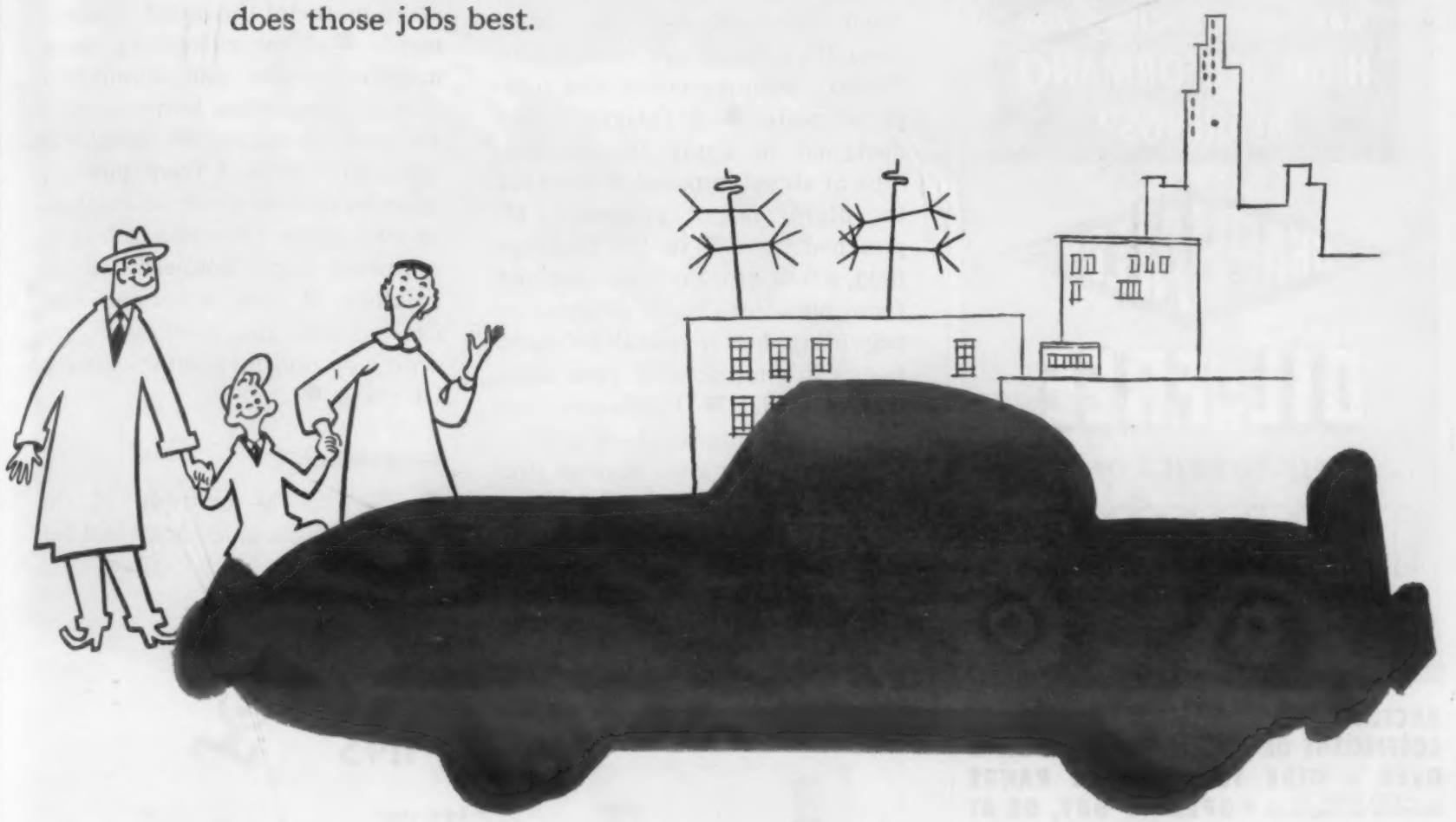

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## Materials Review

powders is analyzed and found to hold promise. ■ Rare earth magnesium alloys are found suitable for use at high temperatures, to 500 and 700 F.

**August**

■ The world's largest die casting machine—claimed capable of turning out die cast engine blocks in aluminum, is demonstrated to automobile manufacturers by Doehler-Jarvis and Kaiser Aluminum and Chemical. ■ U. S. Steel demonstrates the high strength of pressure vessels fabricated from quenched and tempered plate. ■ A fatigue tester designed to apply the random type of stress imposed on aircraft in flight is programmed by punched tape. ■ In the coatings field, a new paint oil base derived from butadiene holds promise of providing better metal to paint bonds, higher scratch resistance for enamels. ■ Photo-sensitive anodized aluminum sheet goes on the market for such uses as dial faces, name plates, etc. ■ A boron modified mild steel from England offers the unusual combination of good weldability and high strength. ■ Mylar applications begin to boom, with a new vulcanized-fiber Mylar-sheet insulating material the latest development. ■ New refractory hard metals—borides and aluminides possess properties between metals and ceramics. ■ Synthetic mica, hot pressed from powder, calendered into sheet or combined with glass, promises to lead to improved high temperature insulators. ■ The American Can Co. reveals the results of research on finding a substitute for tin plate. ■

**Irradiated polyethylene** was introduced as a heat resistant plastic.

**September**

■ The ASTM critique of the validity of the salt spray test for


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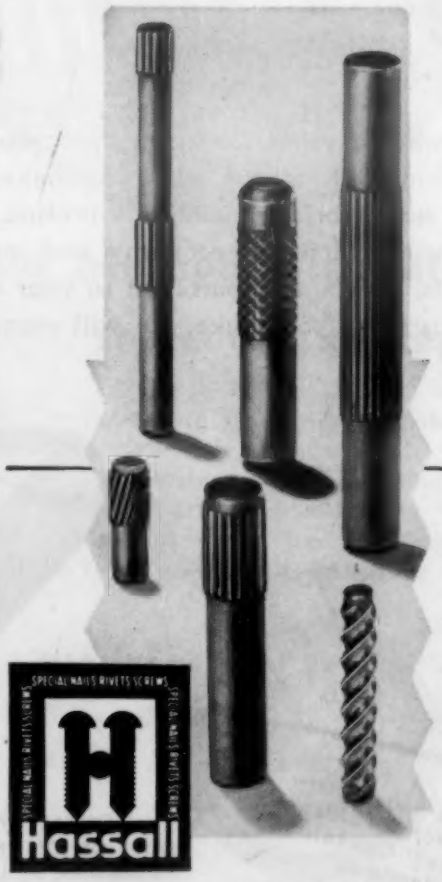

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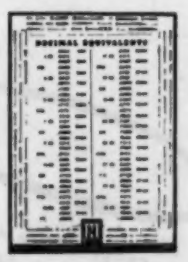

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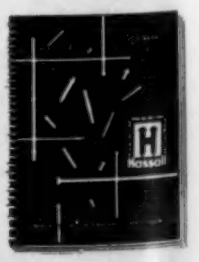

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Furnace Muffle 15' long. Stanwood Furnace Parts assure maximum service.

✓STANWOOD HEAT TREATING EQUIPMENT is designed for your *Specific Needs!*

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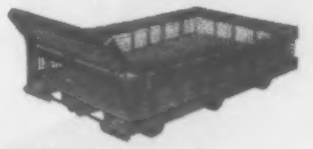

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**TUBING:** Maximum diameter 1" x .050" wall

**WIRE:** All sizes down to .0045" diameter also squares, rectangular and odd shapes.

In addition to laminated materials we also furnish alloyed gold and silver in sheet, wire or tubing form.

The many varied applications of our materials cannot be listed here, but you are cordially invited to inquire for information regarding your requirements.

*The Home of IMPROVED Service*
*Rhode Island's largest manufacturer of Laminated Metals*

The IMPROVED SEAMLESS WIRE COMPANY
INCORPORATED 1898
775 Eddy Street, Providence 5, Rhode Island

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## Materials Review

copper-nickel-chromium plating spurs a number of developmental programs for a better test. ■ Irradiation studies on plastics continue, with the silicones showing promise due to rapid crosslinking under radiation. ■ A new four-step process for joining ceramics to aluminum involves coating the ceramic with aluminum alloy, machining, and brazing to aluminum component. ■ The NBS announces ceramic coatings with low neutron cross sections for use in reactors under corrosive conditions. ■ The new sulfur bearing tool steels are analyzed, shown to demonstrate improvements over conventional types. ■ 5000-lb ingots of 24S aluminum pass soundness tests for use in the heavy press program forges. ■ General Cable announces importation of a method of sheathing cables in aluminum by direct extrusion. ■ Bart Laboratories develops an electroplating process for depositing nickel directly on aluminum. ■ A black nylon molding compound from Du Pont promises no ultra violet degradation in outdoor exposed applications.

**October**

■ M. W. Kellogg introduces fluorocarbon rubbers having properties promising for specialty use where resistance to corrosion and heat are important. ■ A silicone fabric finish that imparts water and stain resistance, improved hand and better wear properties to common upholstery an apparel fabrics. ■ A stronger, high-temperature polyester, reinforced by glass fibers, is revealed by Naugatuck Chemical Div. of U.S. Rubber to withstand high temperatures better than aluminum or magnesium. ■ A new patented process of injection molding unplasticized polyvinyl chloride is used to make

**Plastic pipe** and tubing use increases.

# New epoxy adhesive bonds metal to metal without heat or pressure

If you are joining metal to metal with mechanical fasteners, a new Armstrong epoxy adhesive—J-1151—may make possible important savings in labor and materials.

In certain sheet metal applications, J-1151 can replace screws, bolts, rivets, or spot welds. J-1151 cures at room temperatures, and resulting joints develop tensile strengths as high as 2,000 psi. Only enough pressure to insure contact is needed.

An important economy of bonding with J-1151 is that there are no surface spots or dimples to be removed before finishing, as is often the case with spot welding.

Additional savings are possible with J-1151 because the adhesive bond is continuous, distributing the stress evenly over the entire bonded area. This often results in greater strength and rigidity in the assembly, and it may even permit the use of lighter gauge metals.

For more information on J-1151 or other Armstrong Adhesives, write for a copy of our 1954 manual, free to industrial users. Armstrong Cork Co., 8001 Dunbar Street, Lancaster, Pa. In Canada, 6911 Decarie Blvd., Montreal.

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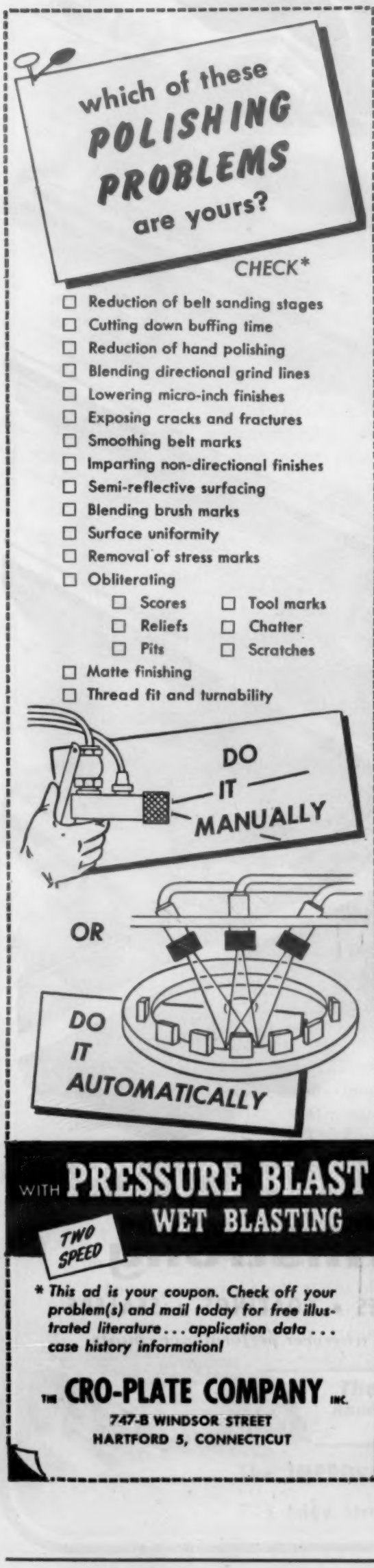
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POLISHING
PROBLEMS
are yours?
CHECK*
☐ Reduction of belt sanding stages
☐ Cutting down buffing time
☐ Reduction of hand polishing
☐ Blending directional grind lines
☐ Lowering micro-inch finishes
☐ Exposing cracks and fractures
☐ Smoothing belt marks
☐ Imparting non-directional finishes
☐ Semi-reflective surfacing
☐ Blending brush marks
☐ Surface uniformity
☐ Removal of stress marks
☐ Obliterating
☐ Scores ☐ Tool marks
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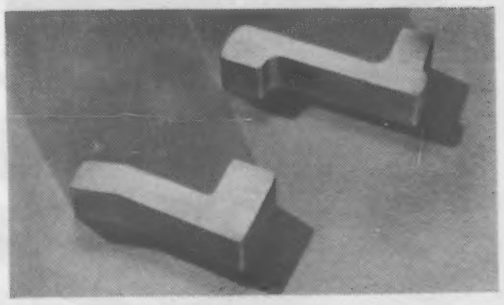
## Materials Review



**Hot steel extrusions** boast low tooling cost.

pipe fittings, is expected to broaden the applications of the material. ■ New brush plating developments are revealed which should increase the number of applications of this simple plating process. ■ The wraps come off a new type of ceramic coating which is chemically deposited on almost any clean surface and can be applied at only a few hundred degrees Fahrenheit. ■ Chemical milling of aluminum by etching shows up well under analysis, holds promise of replacing some expensive skin milling processes. ■ A review of super high strength structural steels shows that some, developed for aircraft use, can be heat treated to strength levels of 200,000 to 300,000 psi.

### November

■ A new solid catalyst is announced by Armour Research Foundation that promises to reduce the price of furfuryl resins. ■ Union Carbide and Carbon announces that it will produce titanium by sodium reduction process. ■ The U. S. Army demonstrates a lightweight plastics barge employing unique sandwich construction techniques. ■ Sudbury Cobalt begins to flow from International Nickel Co.'s new electrolytic lines at the Port Colburn refinery, marking the first production of metallic cobalt in Canada. ■ Stainless steel containing columbium is approved for welded pressure vessel construction. ■ Plastics sandwich materials for service in the temperature range 300 to 500 F make use of foamed phenolics, silicones, many glass reinforced cores and facings. ■ Creep is reduced in nylon by irradiation. ■ Tooling developments include hot

## FOSBOND FORUM

This column carries quotes from technical papers delivered on the subject of phosphate coating; answers questions about the use of Fosbond, Pennsalt's trouble-free phosphatizing process.

### FOSBOND CLEANERS AND ACTIVATORS

Pennsalt's study of cleaning prior to phosphatizing has resulted in a group of specialized cleaners. Now available with several Fosbond cleaners is another remarkable product—ACTIDIP. When incorporated into the phosphatizing cycle, Actidip refines crystal size, lowers coating weights, improves adherence of the finish to the metal. Basically Actidip is a compound containing titanium which when added to water forms a colloidal suspension. Since acquiring patent rights, Pennsalt has developed manufacturing methods that make Pennsalt Actidip® more effective than similar compounds.

### WHAT DOES ACTIDIP DO?

Actidip promotes the formation of a fine, uniform phosphate coating in the subsequent phosphatizing operation, which is much duller when viewed in the light. The surface is far better prepared for the application of paint. There is little loss in gloss. Corrosion resistance is improved. Remember that Actidip cannot be used alone. It must be part of the regular Fosbond cycle.

—J. W. Carroll, Inorganic Research Dept., Pennsalt Whitemarsh Laboratory

**QUESTION—**

How much can Actidip lower my use of phosphatizing solution?

**ANSWER—**

Up to 50%. The use of Actidip in the Fosbond cycle reduces both the chemical consumption and sludge formation, and at the same time obtains a superior product.

**QUESTION—**

How are mandrel tests used by Pennsalt to examine the flexibility and adhesion of the paint finish over a phosphate coating?

**ANSWER—**

In mandrel tests, in which the steel panel is bent over a conical mandrel and given a 90 to 180° bend, untreated painted surfaces offer no resistance to flexing. Panels treated with Fosbond have a paint film with enough "play" to take the severest test designed. There is no flaking of the film from the panel. Cracking of the paint film along the bend of the panel is non-existent. Write for test panels treated with Fosbond.

Send us your questions.
For complete technical information about subjects briefed in the FOSBOND FORUM, write: Customer Service Dept., Pennsylvania Salt Mfg. Co., 1011 Widener Bldg., Phila. 8, Pa.

# Fosbond helps add buy-appeal to McCray KOLDFLO cabinets

McCray KOLDFLO cabinets for ice cream, frozen foods and meats are widely used in self-service stores and super markets from coast to coast. Superbly engineered for their basic job of holding low temperatures within, they also have to do double-duty as silent salesmen, present foods in an attractive way. Their handsome high gloss, high baked white enamel finish, *locked on* with Fosbond®, is a big factor in their famous eye-appeal.

Fosbond 61, applied to both the zinc and steel surfaces of McCray cabinets, creates an ideal base for the organic finish—making it easier to apply, and promoting a smoother coating "locked" to the underlying metal. With Fosbond, McCray has obtained excellent adherence of finish to metal, a superb quality outer finish, and top production.

In addition to the necessary Fosbond materials, Pennsalt also offers to users *continuing* technical assistance to keep operations smooth-running, trouble-free. And behind Fosbond stands Pennsalt—a major chemical producer with long experience in the metal processing field.

If your plant and product would benefit from a *better* phosphatizing process and the merchandising value of the Fosbond-Good Housekeeping emblem, you ought to know more about Fosbond. Let us make a survey of your finishing operation (takes but a few hours... no obligation). Write: Customer Service Dept., Pennsylvania Salt Manufacturing Co., 1011 Widener Bldg., Phila. 7, Pa.

FOSBOND

Pennsalt Chemicals

Pennsylvania Salt Manufacturing Co.

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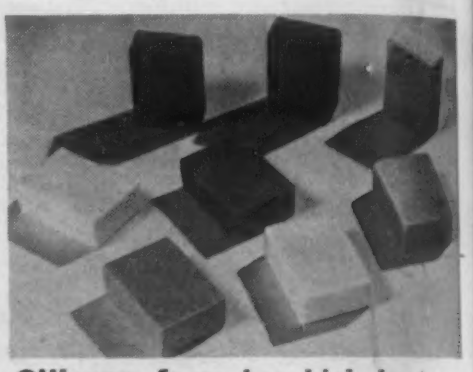
forming titanium at 1000 F on plastics dies (insulated with glass fiber). ■ Silicon carbide bonded with silicon nitride shows twice the high temperature strength of regular grades, can be formed into close tolerance parts. ■ At the metal show the Rollbond technique is introduced for forming integral tubes in sheet. ■ Linde Air Products introduces a molecular sieve.

**December**

■ Metal fatigue emerges as the killer responsible for the Comet jet airliner disasters. ■ Mylar prices are reduced as Du Pont's new plant in Circleville, Ohio starts rolling out the sheet in volume. ■ Dacron felt—batt stitched with its own filaments, offers properties not attainable in wool for high temperature filters, etc. ■ A glass-fiber plastics laminate consisting of sheets of epoxy resin reinforced by parallel glass filaments is introduced by Minnesota Mining and Manufacturing. ■ Other developments include an improved glass reinforced plastics extrusion process and pre-impregnated mat which gives good dimensional and electrical properties. ■ Ductile steel parts from iron powder with strength equivalent to wrought steel are produced by new process. ■ Shell mold casting costs may be sliced drastically if a cheaper binder proves out. ■ Titanium for aircraft parts is hot extruded with tolerances and in shapes identical to that of aluminum.



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⅛" slot cast to .125+.002 inches to make a snug fit for .124 bar which passes full length of 4" long slot.

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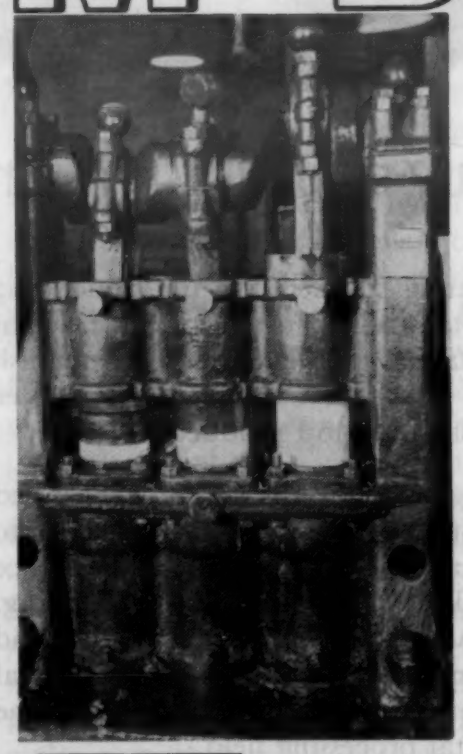

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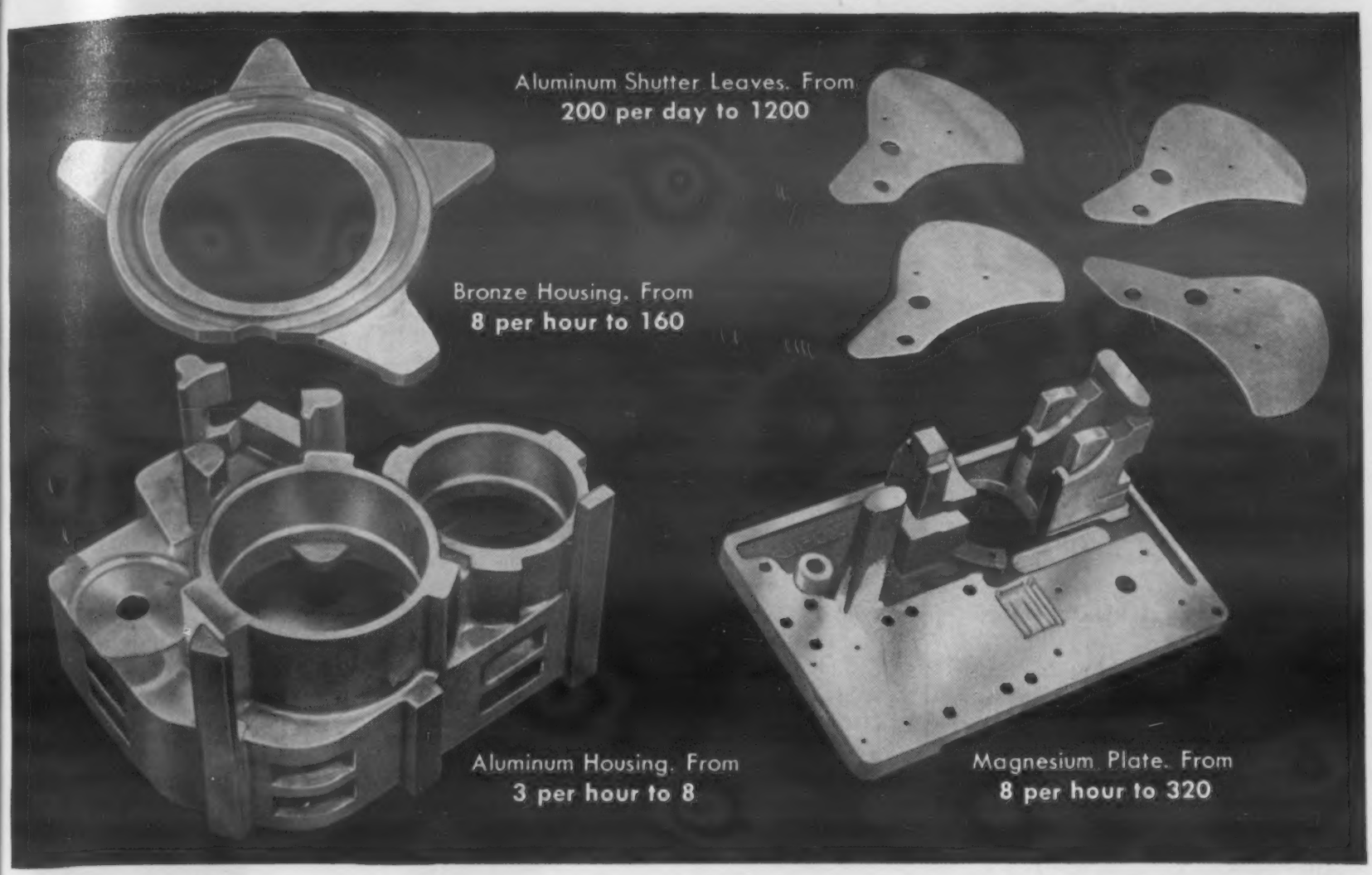
Aluminum Shutter Leaves. From
200 per day to 1200
Bronze Housing. From
8 per hour to 160
Aluminum Housing. From
3 per hour to 8
Magnesium Plate. From
8 per hour to 320

*Camera Maker finds...*

# HONITE Barrel Finishing Saves $25,000 in 3 Months!

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The parts shown above were formerly deburred and finished by hand—a slow, costly job. Now, with the HONITE Barrel Finishing Method costs have been cut to the bone, with better, more consistent finishes. The company deburrs and finishes an average of 150 different lots of parts a week—has found that HONITE Barrel Finishing Methods will do a perfect job on everything from tiny washers and hair-thin shutter leaves to 32-pound bull gears, and even on pieces with tolerances of less than .0002"!

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*News about*
COATINGS for METALS
*Metallic . . . . . Organic . . . . . Decorative . . . . . Protective*

# Protective plastisols gain new versatility

## Make shorter work of finishing problems

When up against a finishing problem, many engineers and designers like to get the opinions of a finishing specialist. They prefer to consult a company that knows many types of finishes.

Because United Chromium has developed plating processes, specialized organic protective coatings, and a wide line of chromate finishes, it can be a real help in suggesting the best type of finish to meet service, appearance and cost requirements.

### ELECTRODEPOSITED COATINGS

Unichrome Copper, Nickel and SRHS Chromium comprise the first matched set of plating processes. This means one source, one responsibility for proper operation which in turn means the finest finish of its kind plus smoother running production.

### UNIQUE ORGANIC COATINGS

Developed to meet unusual requirements, Unichrome lacquers, synthetics, enamels are now available in a broad range to block corrosion, add long life to the eye appeal of a product.

### CONVERSION COATINGS

Chromate treating strengthens corrosion resistance of zinc die castings and plate. It offers an easy, economical way to finish. With Unichrome Dips, high quality also is obtainable — quality measured in durability and appearance.

* * *

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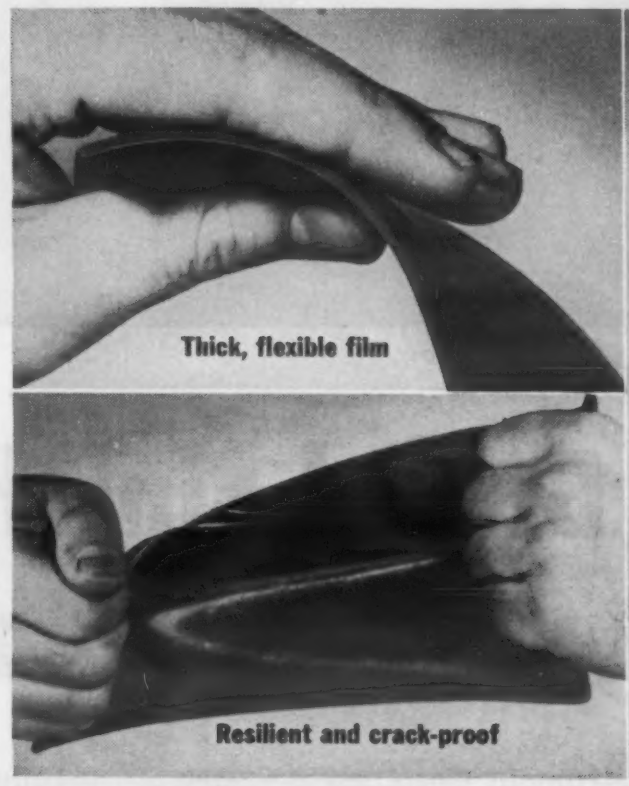
*Advantages of Unichrome heavy-duty vinyl compounds now obtainable even with sprayed coatings*



Resists many corrosives

PLASTISOL compounds are liquids, which when heat cured, build up vinyl plastic finishes that look and feel like rubber, but there the resemblance ends. Plastisols offer truly remarkable chemical resistance, which is further fortified by the tough, substantial film thickness achieved in one coat.

### SEAMLESS, THICK-FILM PROTECTION

Any metal surface that can be uniformly baked can now be strongly protected against severe and corrosive service conditions by Unichrome 4000 Series Plastisol Compounds—or the new Coating 5300. The first practical *sprayable* plastisol, Unichrome Coating 5300 fills the need for a plastisol suitable for application to products too large to be dip-coated.

A 20 mils thick, non-sagging coat can be applied even to cold vertical surfaces in just one application with Coating 5300. That's 5 to 20 times thicker than ordinary coatings. Unichrome Series 4000 Plastisols, which are applied by almost any other conventional method, produce coatings up to 3/16" thick. Plastisols can do jobs for which sheet materials have been used.

### CHEMICAL RESISTANCE OF VINYLS

Unichrome Plastisols offer seam-free and pore-free protection against acids, alkalies, water, salt solutions and many other corrosive agents. They bake into an abrasion-resistant resilient coating that doesn't crack, chip or tear. With such protection, ordinary metals can often be used in place of costly alloys.

The chemical resistance, physical toughness, electrical insulating properties, and speed of curing of Unichrome Plastisols combine to offer engineers a new tool for protection and finishing. Send for Bulletin VP-1.

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